FINAL REPORT

Contract FA 64WA-5186

INVESTIGATION INTO THE RETRIEVAL INDEXING AND SEARCHING SYSTEM

September 1965

Prepared for

FEDERAL AVIATION AGENCY

Office of Headquarters Operations

by

JONKER BUSINESS MACHINES, INC.

Federal Systems Division

Washington, D. C.

FINAL REPORT

Contract No. FA64WA-5186

INVESTIGATION INTO THE RETRIEVAL INDEXING AND SEARCHING SYSTEM

September 1965

Prepared by

Douglas E. Berninger
Rinah T. Korenman
Paul V. Elholzer

This report has been prepared by Jonker Business Machines, Inc. for the OFFICE OF HEADQUARTERS OPERATIONS, FEDERAL AVIATION AGENCY, under Contract No. FA64WA-5186. The contents of this report reflect the views of the contractor, who is responsible for the facts and the accuracy of the data presented herein, and do not necessarily reflect the official views or policy of the FAA. This report does not constitute a standard, specification or regulation.

JONKER BUSINESS MACHINES, INC.
Federal Systems Division
Washington, D. C.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

Figure

LIST OF TABLES

Table

EXECUTIVE SUMMARY

During the contract period, Jonker processed 10,000 technical reports for the FAIRS, increasing the size of the central collection to 16,450 reports. The reports, covering the gamut of subjects within aviation and representing the technical information that best describes progress in that field, came from numerous government and industrial organizations, but the largest single source was the Federal Aviation Agency itself: 2,262 were generated by the Agency and its contractors. Jonker's primary objective was to prepare the incoming technical information for its subsequent retrieval by users of the system. In brief, Jonker identified the important concepts in each report, indexed these concepts with suitable keywords from a controlled vocabulary, and entered the retrieval information into the system's files and searching tools.

Consistent with the concept of centralized processing-decentralized operation, the cost of Jonker's work was incurred only at the Headquarters, while the retrieval information and searching tools were economically duplicated for use in the Regional Offices, the Aeronautical Center, and NAFEC. The Agency had created these satellite information centers to serve personnel whose remote work sites might otherwise leave them without the benefit of up-to-date technical report information. Users of the system, either at the Headquarters or the field installations, can communicate with the system through the published Thesaurus of FAA Descriptors which, as the system's official language, links them to indexers who put reports into the system.

Jonker continued development of the Thesaurus to ensure that it reflects the latest advances and terminology of aviation and, in a special study, measured the influence of the Thesaurus and of indexing and searching techniques on the system's performance. Data were acquired to tell how well the FAIRS could retrieve documents that were relevant to users' needs and, conversely, how well it could avoid nonrelevant documents. The system responded satisfactorily to a variety of conditions, but revealed several areas where improvements can be made.

Specific recommendations are offered to strengthen report acquisitions, indexing and shelving, and to improve the Thesaurus by statistical analysis of its use. Other recommendations are devoted to ways of increasing the users' satisfaction with the FAIRS. A training-instructional aid could broaden the usefulness of the system, particularly in the field installations. Improved searching techniques also could help. Jonker has recommended that internally developed data from searching and indexing be used as "feedback" in guiding the future growth of the system. Jonker has recommended that special attention be given to the improvements that might be achieved by automatic data processing techniques, compatible with the punched paper tape master file of the retrieval information that Jonker prepared.

INTRODUCTION

This final report summarizes the work that Jonker Business Machines, Inc. has accomplished for the Federal Aviation Agency under contract FA 64 WA-5186: Investigation into the Retrieval Indexing and Searching System. The subject of the contractual study was the Federal Aviation Information Retrieval System (FAIRS), which serves diverse information needs of the Agency's technical and administration personnel.

Before the present contract, FAA had made several basic decisions about the FAIRS which governed Jonker's work. For one, the Agency had decided to develop a controlled vocabulary especially suited for civil aviation, but compatible with the Thesaurus of ASTIA Descriptors. The vocabulary, the Thesaurus of FAA Descriptors, had been developed under an earlier contract as the first 5,000 reports were processed for the system.

Those first reports were implemented into the search and retrieval tools that the Agency had selected for the FAIRS. These tools include an identifier file for special nomenclature, a 3 x 5 accession card file, microfilm copies of FAA reports, and Termatrex which the Agency had selected for subject searching.

Prior to Jonker's work, moreover, the Agency had decided to exploit the concept of centralized processing-decentralized operation by creating satellite information centers in its field installations. The Agency chose to bear the costs of report analysis and processing at the Headquarters, but made provisions to duplicate the search and retrieval tools for each Regional Office, the Aeronautical Center and NAFEC.

Another decision typified the Agency's desire that the report processing techniques currently used in the FAIRS be compatible with automatic data processing techniques that might be used in the future. To ensure that compatibility, FAA required that Jonker enter the information needed for retrieval onto punched paper tape suitable for computer input.

Under these precedents established by the Agency, Jonker helped develop the FAIRS to operational capacity by work on four major tasks between July 1964 and August 1965:

1. Assigning descriptors and identifiers to reports to prepare them for subsequent retrieval.

2. Expanding, developing, and updating the system's vocabulary: the Thesaurus of FAA Descriptors.

3. Implementing the technical reports into the system.

4. Investigating the retrieval effectiveness of the system.

Although this report summarizes all the work undertaken by Jonker on the completed contract, it concentrates on these four major tasks. The report discusses the results of the work and the problems that were encountered, and it provides recommendations for future procedures.

WORK ACCOMPLISHED

Descriptors and Identifiers

During the contractual work, 10,000 technical reports were prepared for system input by coordinate indexing. Reports were indexed to an average depth of 9.35 descriptors each, but the descriptor assignments varied from 2 to 25 per report.*

A total of about 6,280 identifiers were also assigned to the reports. That average of .628 occurred while the range in identifier assignments was from 0 to 13.*

The Thesaurus

The Thesaurus of FAA Descriptors (1st Ed.), July 1964, was updated with new terminology that was needed to adequately index the reports: 356 new descriptors were added to the Thesaurus, but 176 established descriptors were deleted for lack of use. The net increase of 180 descriptors raised the total now in the vocabulary from 2,813 to 3,093, of which approximately 120 are not in the ASTIA Thesaurus of Descriptors. The "use" references increased from 1,848 to 1,959.

The exhaustive structures and cross-references among new and old terms were incorporated into a final, second edition of the Thesaurus. Camera-ready copy of that edition was delivered at the completion of the contract. Updated EAM cards, the storage media on which the Thesaurus is maintained, also were prepared and delivered to FAA.

System Input

The 10,000 reports indexed were entered into the Termatrex system which had been installed by FAA for searching its technical report literature. At the present time, two Termatrex card decks are used for the total of 16,643 reports in the collection.

An accession record file was maintained for each of the technical reports indexed. FAA was able to provide most of the printed 3 x 5 abstract cards. Because the cards were not available elsewhere, catalog cards for 4,696 of the reports, well over FAA's contractual estimate that one-third of the reports would need cards.

---

* These figures are comparable to those reported by a previous contractor, where the average indexing depth was 9.2 with a range of 1 - 40; and the identifiers averaged 0.95, ranging from 0 - 12.

Jonker also posted accession numbers for approximately 6,280 of the 3 x 5 cards in the Identifier Card file. Of these, about 985 identifier cards already in the file were updated, and approximately 4,000 new identifiers were added to the file, causing its size to grow from about 2,700 to 6,700 cards.

The 10,000 Document Analysis Worksheets were typed as (camera-ready copy) on a Flexowriter, which simultaneously produced a punched paper tape master file containing all cataloging and indexing information. The master tapes with accompanying correction tapes were delivered to FAA.

Index Files for Instruction Manuals

Index files on 3 x 5 cards were provided for 4,664 type numbers from instruction books and maintenance manuals (not technical reports) that were located in the FAA Headquarters Library and in the reference file at NAFEC. Jonker prepared three of the files, one each for the Headquarters, Aeronautical Center, and NAFEC. Each file contained three separate decks arranged alphabetically by corporate source, alphabetically by subject heading, and numerically by type numbers.

Legal Memoranda and Congressional Materials

The review and collation of legal memoranda and congressional materials were completed in November, 1964, early in the contract. A separate final report for that task, submitted at that time as specified by the contract, has been included as Appendix A of this report.

Retrieval Effectiveness

Studies were conducted to determine the system's retrieval effectiveness according to how well it avoided non-relevant documents (Relevance Ratio) and how well it retrieved relevant documents (Recall Ratio). The performance of the system, measured under different conditions, was derived from the test data as follows:

Relevance Ratio: 35.4 - 59.3%
Recall Ratio: 22.2 - 73.3%

Although these ratios have little meaning by themselves, it will be shown later that the effectiveness tests helped explore the internal workings of the system: indexing techniques, the Thesaurus, and searching procedures.

DESCRIPTION

General

The general framework for the technical report processing used during the contractual work has been identified within the Flow Chart presented in Appendix B as Figure B-1. Because the illustration ties together the efforts that occurred between the time a report was first made available for processing and the time the report was entered into the system, it should be a useful reference for the detailed explanations that are presented below.

Document Analysis Worksheet

The heart of the technical report processing was the Document Analysis Worksheet, FAA Form 3328, shown in Figure B-2. The DAW was used not only as a worksheet for indexing, cataloging, editing, proofreading, and Termatrex drilling, but also as a "source document" for the Flexowriter generation of punched paper tape that is suitable for computer input.

To satisfy the ADP requirement, it was necessary for FAA to redesign the DAW before technical report processing began. The size (number of digits) needed for each bibliographic field on the Worksheet was determined and each field then was assigned a machine-readable identification code that would appear in the paper tape. Since these codes and sizes are vital for paper-tape-to-magnetic-tape conversion, they are presented in Figure B-3. The form's margins also were designed so that it could be machine-fed through the Flexowriter.

Indexing

Technical reports were prepared for input to the system by coordinate indexing. For coordinate indexing, indexers select descriptors that correspond to the important concepts expressed by a report. Although the descriptors can be manipulated individually, they can be used in conjunction with each other to characterize the subject matter of reports.

At FAA, descriptors (and their numerical codes) were selected from the Thesaurus of FAA Descriptors (1st Ed.), July 1964, by experienced indexers who have had professional training in the subjects covered by the FAA technical report collection. To promote uniformity among

indexers, guidelines[1]* were established prior to the start of indexing. The guidelines, coordinated with and approved by the FAA Project Officer, governed the depth and specificity of indexing and cited reference authorities for definitions and terminology.

The guidelines' procedure called for descriptors to be entered on the DAW at two levels: primary and secondary. Primary terms, designating the subject matter of greatest importance in each report, were preceded by an asterisk on the DAW's.

Indexers also entered identifiers onto the Worksheets to cover specific topics in the reports, such as airplane models, airport names, equipment designators, helicopter models, project names, etc., that were not covered by descriptors.

Each completed DAW then was edited to provide even greater consistency over the indexers' selections of descriptors and identifiers.

Updating the Thesaurus

Whenever suitable descriptors could not be located in the Thesaurus of FAA Descriptors (or in the ASTIA Thesaurus of Descriptors), indexers established new descriptors for inclusion into the Thesaurus. Each suggested vocabulary change was transacted via a Term Justification Form (TJF) such as the one shown in Figure B-4. The TJF defined each new term and explained how it would affect the existing Thesaurus terminology by portraying the new term's structure (cross-references and generic-specific relationship). TJF's were edited by the Jonker Project Manager before the suggested new terms were submitted to the FAA Project Officer for approval.

Approved terms and their structures were keypunched and merged into the Thesaurus, which has been maintained on EAM cards; rejected terms were given lesser status as identifiers. Descriptors which had been established in the 1st Edition of the Thesaurus, but which were not used for the indexing of the first 10,000 reports, were deleted from the 2nd Edition of the Thesaurus.

To further assure the quality of the revised Thesaurus, updated printouts were prepared at the midpoint and the end of indexing. Each printout was carefully edited to correct any weaknesses in the descriptors' structures.

---

* Numbers refer to references presented later in a separate section.

Implementing Reports into the System

Technical reports were implemented into the system by entering the information on the Worksheet into the respective files: the accession record file, the identifier file, and the Termatrex card deck. The completed Worksheets also were filed after they had been typed on a Programmatic Flexowriter. As a by-product of typing the DAW's, the Flexowriter also produced an 8-channel punched paper tape master file containing the reports' complete bibliographic information as well as all descriptors and identifiers.

The accession record file was expanded by serially filing a catalog card for each report. Where printed cards were not provided with the reports by FAA, Jonker produced the necessary 3 x 5 cards (Figure B-5) on the Flexowriter by recycling a second by-product paper tape.*

The identifier file was updated during the contract period by posting report accession numbers onto applicable 3 x 5 Identifier cards such as the one shown in Figure B-6. Additional Identifier cards were prepared as required.

To provide the FAIRS' capability for subject searching, the indexed reports were entered into the Termatrex system. The input to Termatrex was made via an automatic drilling device (J-400) that read verified punched cards, keypunched from proofread Worksheets.

As the deck of Termatrex cards for the FAA Headquarters was drilled, additional decks were drilled for each of the seven Regional Offices, and for NAFEC and the Aeronautical Center. By allowing a reduced cost per deck, the simultaneous input for Termatrex cards stands as a major example of the economy effected by the concept of centralized processing-decentralized operation.

During Termatrex card drilling, moreover, the mandatory "generic posting" of index terms was performed. Generic posting requires that the card for a generic descriptor be posted (drilled) when any of that descriptor's specific terms have been selected for indexing. As an example taken from the Thesaurus, CERAMIC MATERIALS (a generic term) is broader than GLASS (the specific term); with generic posting, CERAMIC MATERIALS would be posted, not only whenver it was used for indexing, but also whenever GLASS was used for indexing. (The merits of generic posting are discussed later in the report.)

Preparing Files for Manuals

Three index files for maintenance manuals and instruction books (one each for Headquarters, for NAFEC, and for the Aeronautical Center) were prepared by the procedure illustrated in Figure B-7. Jonker's work on the task, which began after FAA had assigned subject headings to each type number in the manuals and books, was to prepare master 3 x 5 cards that displayed each type number and subject heading and the corporate source which produced the manual. As shown in the example of Figure B-8, the title, date, and contract number of each manual were added to the master cards.

The first group of manuals that were processed came from the collection at the Headquarters Library. The finished master cards for them then were compared to the collection of manuals and books in the file at NAFEC, identifying additional manuals for processing. During the comparison, the file location of each manual was indicated on the card, so that the completed cards would serve as a consolidated index file for the Agency.

Jonker printed nine copies of each master card and separated them into three files, each containing three identical decks of cards. To complete each file, one deck was arranged in order alphabetically by corporate source, one numerically by type number, and one alphabetically by subject heading.

Testing the System's Effectiveness

The procedure for conducting tests of the system's retrieval effectiveness is explained in the next section with other material pertinent to that study.

---

* To maintain consistency among corporate sources for these cards, Jonker catalogers used the AEC's Corporate Author Entries.

TESTING THE SYSTEM'S RETRIEVAL EFFECTIVENESS

Description

As part of the contractual work, the FAIRS was tested to determine how effectively it could retrieve reports for given search questions. The test was designed to provide information on the effects of generic posting, any weakness in the Thesaurus as a searching tool, optimum procedures for searching, and the adequacy of indexing. Although the complete plan for conducting the test is presented in Appendix C, pertinent details are repeated in this section.

In brief, the entire 10,000-document report collection, designated Document Set A, was searched with ten test questions. The questions, identified in Figure D-13, were selected randomly from those that had been previously submitted for actual searches by FAA personnel.* All available reference questions were first reviewed and separated into a file of candidate test questions. A question was not considered applicable if its subject matter was no longer of interest or value to the respective FAA user. A question was also unacceptable if its "author" were unwilling to participate in the test, because those subject specialists were later asked to judge the reports retrieved by the system for their relevance (or non-relevance) to the respective question. From the individual users' assessments (Appendix D), the system's performance was expressed by its Relevance Ratio and its Recall Ratio.

The basic ingredients for those two ratios are identified in the 2 x 2 contingency table of Figure 1. From the notations, the Relevance Ratio can be expressed as:

$$\text{Relevance Ratio} = 100 \times \frac{\text{Reports relevant and retrieved}}{\text{Total Reports Retrieved}}$$

or as the percentage of relevant documents retrieved out of all those retrieved. (The "non-relevance ratio" might be considered to represent the noise level of the system's retrieval.)

---

* It was considered useful to re-impose these questions on the system, because the report collection had grown by over 50% (from 6,443 to 10,000) since the original searches had been made.

Figure 1 - INGREDIENTS FOR RELEVANCE AND RECALL RATIOS

		RETRIEVAL STATUS		
		RETRIEVED	NOT RETRIEVED	
RELEVANCE JUDGMENT	RELEVANT	Reports RETRIEVED and RELEVANT	Reports NOT RETRIEVED but RELEVANT	Total Reports RELEVANT
	NOT RELEVANT	Reports RETRIEVED but NOT RELEVANT	Reports NOT RETRIEVED and NOT RELEVANT	
		Total Reports RETRIEVED		Size of Collection

The Recall Ratio can be expressed as:

$$\text{Recall Ratio} = 100 \times \frac{\text{Reports relevant and retrieved}}{\text{Total reports relevant}}$$

or as the percentage of relevant retrieved out of all those reports which should have been retrieved (those judged to be relevant by the user).

To derive the Recall Ratio, it became necessary to determine how many reports in the collection were relevant to each question: not only from among the reports retrieved, but also from among those not retrieved. In the tests, however, the entire collection was not assessed for each question. Instead, the assessments were made from within a 10% sample comprising 1,000 randomly identified reports (Document Set B), and the results from searching that sample were then extrapolated to the collection.

In a special test to expand the data for the Recall Ratio, moreover, 20 questions were compiled from the texts of technical reports (Figure D-14). These "source documents" were assumed to be relevant to the question that they inspired; hence, retrieval from these 20 questions was not judged: retrieval was successful if the source document was retrieved, and unsuccessful if the source document was missed.

Even though the system's performance could be expressed in these two ratios, further investigations were conducted to seek the causes for the system 1) retrieving non-relevant material and 2) failing to retrieve relevant material.

As a first step in isolating the causes for retrieval failure, the test procedure required each question to be searched by four different strategies. All four strategies required the use of the Thesaurus, but they differed in the level of descriptors (generic vs. specific) that were used.

Strategy A was composed with the descriptors either generic or specific, that most directly corresponded to the terminology of the written search question. In Strategy B, only generic terms were used. The general intent of this strategy was to retrieve as many reports as possible. Strategy C used the same generic terms that were used in Strategy B, but the non-pertinent specific descriptors for each generic term were substracted. Strategy D used both generic and specific descriptors, but did not coordinate two descriptors of the same level; that is, the applicable generic terms were coordinated only with the applicable specific terms, and vice versa. This method was comparable to one found successful at E. I. duPont.[2]

Relevance and Recall Ratios

The retrieval results of the tests, presented in Appendix D, have been summarized in Tables I and II. The data of Table I shows that the highest Relevance Ratio for the system was 59.3%, achieved with Strategy

TABLE I

RETRIEVAL DATA FOR RELEVANCE RATIO

Question Number	Strategy A		Strategy B		Strategy C		Strategy D	
	Total Relevant Retrieved	Total Retrieved	Total Relevant Retrieved	Total Retrieved	Total Relevant Retrieved	Total Retrieved	Total Relevant Retrieved	Total Retrieved
57	7	9	11	33	*	*	*	*
85	3	5	9	30	9	29	9	25
88**	0	0	4	7	4	7	3	6
109	11	11	14	41	14	32	13	16
111	0	5	20	83	20	80	6	42
133	1	1	1	5	1	5	1	4
162	19	40	32	77	24	57	30	59
205	6	11	15	61	15	61	15	44
223A	0	0	4	5	4	4	4	5
223B	1	1	2	3	2	3	2	3
270	3	3	32	62	30	45	24	34
Total	51	86	144	407	123	323	107	238
Relevance Ratio	59.3%		35.4%		38.3%		44.9%	

*These strategies were not applicable.

**Data from Document Set B only.

TABLE II

RETRIEVAL DATA FOR RECALL RATIC

(Document Set B)

Question Number	Strategy A		Strategy B		Strategy C		Strategy D	
	Total Relevant	Relevant Retrieved	Total Relevant	Relevant Retrieved	Total Relevant	Relevant Retrieved	Total Relevant	Relevant Retrieved
57	1	0	1	1	*	*	*	*
85	3	0	3	2	3	2	3	2
88	5	0	5	4	5	4	5	3
109	5	4	5	5	5	5	5	5
111	11	0	11	9	11	9	11	3
133	0	0	0	0	0	0	0	0
162	7	4	7	5	7	3	7	5
205	1	0	1	0	1	0	1	0
223A	4	0	4	1	4	1	4	1
223B	1	0	1	0	1	0	1	0
270	7	2	7	6	7	5	7	3
Total	45	10	45	33	44	29	44	22
Recall Ratio	22.2%		73.3%		65.9%		50.0%	

*These strategies were not applicable.

A; the poorest, on the other hand, was 35.4% with Strategy B.

These Relevance Ratios, however, have little meaning until they are coupled with their respective Recall Ratios, for it has long been understood that high Relevance is attained at the expense of Recall; and, conversely, that high Recall, at the expense of the Relevance Ratio. The data of Table II supports that thesis: the highest Recall Ratio (73.3%) of Strategy B was achieved with the lowest Relevance Ratio in the test, and the lowest Recall Ratio (22.2%) accompanied the the highest Relevance Ratio.

Recall data from searches with the 20 source document questions depicted a similar pattern among the four search strategies. That data, presented in Appendix E, are summarized in Table III to show that the highest Recall Ratio of 90% again came from Strategy B and the lowest (70%) from Strategy A.

TABLE III

RECALL RATIOS FROM SOURCE DOCUMENT QUESTIONS

Strategy A	70%
Strategy B	90%
Strategy C	80%
Strategy D	75%

Causes of Failure

After the Relevance and Recall Ratios were established, an investigation was made to determine the causes of retrieval failure by inspecting each of the non-relevant documents retrieved and each of the relevant documents not retrieved during the effectiveness test. The data gathered from that detailed analysis, synthesized into later discussions about features of the system needing attention, has been summarized in Figure 2.

The two major causes of the system's failure to retrieve relevant documents were in searching (43%) and in indexing (38%), and the retrieval of non-relevant documents was caused primarily by searching (33%) and generic posting (44%).

The high percentage of non-relevant reports retrieved by generic posting appears to be a major disadvantage of its use in the system, but it is pointed out later that generic posting was solely responsible for the successful retrieval of 61% of the relevant documents retrieved in Strategy B.

The failures caused by indexing, like those of searching, involve subjective intellectual tasks of selecting important concepts and their applicable descriptors. These, as others have found, are subject to error in any system.

In both kinds of searching errors, the critical aspect was the number of search terms that were coordinated simultaneously, or used in conjunction with each other. The coordination of three of four terms consistently yielded few reports (including few relevant), while the coordination of only two terms yielded more reports (including non-relevant ones).

Figure 2 - SUMMARY OF SYSTEM FAILURES
(Estimated Percentages)

CAUSES	RELEVANT DOCUMENTS NOT RETRIEVED (%)	NON-RELEVANT DOCUMENTS RETRIEVED (%)
SEARCHING		
Too many terms coordinated	24	
Too few terms coordinated		22
Term missing from search	5	11
Improper term used	7	
Term lost through negation (Strategy C only)	7	
INDEXING		
Too exhaustive		4
Not exhaustive enough	11	
Too specific		4
Too generic	12	
Concept omitted	14	
Wrong term used	1	
THESAURUS		
Specific Term missing	1	5
Inadequate term structures	1	1
GENERIC POSTING		44
DISAGREEMENT WITH USERS' JUDGMENT	17	9
TOTAL:	100	100

Comparison of FAIRS to Other Systems

The Relevance and Recall Ratios determined for the FAIRS compare favorably with the same ratios, shown below in Figure 3, developed during tests of other systems. The ratios for the FAIRS also lie within the general ranges established by the Cranfield study:

Relevance Ratio: 10 - 25%
Recall Ratio: 60 - 90%

Figure 3 - TYPICAL RELEVANCE AND RECALL RATIOS
(Reported in 1964 Literature)

Source of Data	Name of Organization	Documents in Collection	Documents in Test	Relevance Ratio	Recall Ratio
3	Navy, BuShips	1000	1000	54.3%	--
		1000	1000	56.4%	53.8%
4	Western Reserve University	(no data)	950	17.7%	75.8%
4	Cranfield	(no data)	950	33.7%	69.5%
5	Air University	6500	6500	65.4%	--
6	E. I. duPont	(no data)	433	51-80%	67-85%
6	E. I. duPont	(no data)	5000	46-74%	31-93%
**	Defense Documentation Center	(no data)	1000	76.7%	19.5%

* Numbers refer to References in a later section of this report.
** Determined from data presented in Reference 2.

Despite the general agreement between the data derived from the present retrieval tests and that from other tests, there remains debate among documentalists about the validity of mathematics being applied to matters as subjective as "relevance." No correlation between a user's real need and his expressed need (the written request) has been made. In one of the test questions, for example, the user judged eight reports relevant, but four months earlier he had found only seven of the same documents relevant.

Subjectivity also was apparent in the tests when, upon inspecting the 105 relevant documents not retrieved by Strategy A, Jonker indexers (who are professionally trained in the subject matter) disagreed with 15 of the assessments that had been made by the FAA staff member. Even if the users' judgments are absolute, as they were assumed during the present tests, it remained difficult to tell with certainty always where the system failed. While there is no clear explanation for every retrieval failure, few other investigators have estimated the influence of subjectivity on the validity of their test data. Some have even acclaimed "precise values," but to their critics dismay.

Because of the subjectivity inherent to so many facets of an information retrieval system, Jonker suggests that the performance of the system, per se, has not been established even though the Ratios are expressed to three significant digits. The mathematics, i.e., the ratios, should be used only in context, and then with great care. In the present tests, moreover, the data is susceptible to criticism because too few questions were used and because the 10% sample of reports (Document Set B) did not produce consistent results. In one case, for example, the user found 11 relevant reports from within that sample and found another 11 from the rest of the collection. Another found 11 relevant in the collection but only 1 in the sample.

Jonker believes, nevertheless, that Relevance and Recall, as they were used in the present tests, can be used to detect trends within an information system and to gauge the gross (never precise) effects of the trends. The two criteria (and the analysis of system failures) highlighted features of the system such as the low retrieval caused by lightly posted descriptors, the lack of day-to-day retrieval data caused by inadequate documentation of searches, the usefulness of "source document" questions to an indexing supervisor, and the use of a searching technique to counter the disadvantages of generic posting. The test, showing its merit outside the realm of Relevance or Recall, helped expose the problems of checking incoming reports for duplicates, of maintaining two separate shelf locations for reports, and of shelving reports in Corporate Source order. These and other features of the system are discussed in later sections of the report.

DISCUSSION

Search Strategy

Taube had written that "most librarians and information people know that, in general, the larger the(document) set retrieved, the more likely it is that the answer will contain irrelevant material and that the smaller the set retrieved, the more likely it is that relevant material will not be recalled."[7]

The results of the present Relevance and Recall tests have reiterated the belief that differing search strategies can cause the system's retrieval to give either high relevance or high recall, although not both. What is more important from the tests, however, is that they have shown how to achieve the desired variation in retrieval results. By coordinating three or even four search terms, the system's retrieval can be reduced to but a few documents. That strategy would be applicable where a user wanted only one relevant report. If only the most generic terms are coordinated as they were in Strategy B, the number of reports retrieved--relevant and non-relevant--increases greatly.

A compromise between the very specific and the very broad was afforded with Strategies C and D. Strategy C offered a slightly higher recall than Strategy B, but employed a cumbersome technique of negations. Strategy D, on the other hand, involved a straight-forward coordination of specific terms with generic terms. Because this Strategy significantly reduced the number of non-relevant documents retrieved without seriously affecting recall, it would appear that Strategy D is optimum for a system that uses generic posting. Strategies A and B remain applicable, however, because they add to the system's ability to respond to the users' needs.

To exploit this ability of the system, the searcher must know whether a specific search or a broad search is desired, and should also know how many reports the user wants. (This last criterion has varied a great deal among users of the FAIRS.)

Search Documentation

From the review of reference questions prior to the effectiveness tests, Jonker was able to detect several weaknesses in the documentation that is presently used for searching in the FAIRS. For most questions, the search records (Figure B-9) lacked notations showing which technical

reports the user had found to be relevant at the time of searching. With no identifying accession numbers for those reports, the Search Question Record, FAA Form 2712, has little or no bibliographic value: if the same search were again requested, it would have to be entirely redone.

Because so few of the Records identified the accession numbers of the relevant and non-relevant reports retrieved for these actual searches, it was impossible for Jonker to compare the results of its tests to the day-to-day satisfaction that users have with the system. That data, if provided on the Record in the future, would easily permit the Agency to compile massive retrieval data similar to that which was developed during Jonker's effectiveness tests. Such a continuing survey of the system would provide valuable feedback on the system's retrieval and users, as well as data that could be used for further investigation of the system.

Documentation for searches can be improved in other ways to strengthen the search procedure in the FAIRS. For one improvement, the written narrative form of the question should be as complete as possible. Many of the Records reviewed by Jonker carried only the searcher's interpretation of the question (not the question itself). Interpretation should be closely tied to use of the Thesaurus. As a good exercise to encourage Thesaurus use before searching, the Search Record should provide space for writing all the candidate descriptors which might be used for searching.

To accomodate the suggested additions of accession numbers and descriptors, space on the Record could be alleviated by deleting the two sections allotted for sub-questions. The suggested revisions in the Search Question Record are shown in Figure B-10.

Generic Posting

Although 93,500 descriptors were posted during indexing, Jonker estimates that generic postings have increased the over-all size of the file by about 50%; that increase is graphically illustrated in Figure 4. Since so many descriptors (those without specific references) were unaffected, however, the density of those which were posted increased by much more than 50%. As shown in Table IV, many postings were increased by well over 100%.

The effect of generic posting on the system's retrieval is quite obvious: the system is unable to yield documents indexed solely under the generic term. Searching with generic terms, in other words, retrieves unwanted reports from the species. Of the non-relevant reports retrieved during the tests, 44% were retrieved solely by generic posting.

TABLE IV

POSTING DENSITIES OF SELECTED DESCRIPTORS

Descriptor	Posting Density	
	Without generic posting	With generic posting
AIR ROUTE TRAFFIC CONTROL CENTERS	205	*
AIRPORT CONTROL TOWERS	83	*
ATC ENROUTE	82	*
POSITIVE CONTROL	37	*
AIR TRAFFIC CONTROL SYSTEMS	889	1023
AIR TRAFFIC CONTROLLERS	165	*
ATC TERMINAL AREA	346	*
AERODYNAMIC CONFIGURATIONS	103	961
AIRCRAFT	497	2134
AIRCRAFT EQUIPMENT	103	481
AIRPLANES	35	1154
COMMUNICATION SYSTEMS	267	742
MECHANICAL PROPERTIES	141	696
PERSONNEL	38	497
TERMINAL FLIGHT FACILITIES	89	824
TEST FACILITIES	127	253

* Generic posting not applicable.

Despite these handicaps, the proponents of generic posting believe that, in general, it permits a system to attain a higher Recall Ratio, knowingly at the expense of high relevance. The data from the present tests, in general, support the use of generic posting in the FAIRS.

For one thing, the tests showed that the "noise" usually associated with generic posting can be reduced by a technique in searching (Strategy D) where coordination of one generic term with another is avoided. In Strategy D the Relevance Ratio was 44.9%, the second highest measured during the test. In Strategy B, on the other hand, generic terms were coordinated, and the Relevance Ratio was the lowest (35.4%).

Although the Recall Ratio for Strategy D (50.0%) was considerably lower than for Strategy B (73.3%), it was found from inspecting documents that the Recall Ratio would have been even lower in all strategies had generic posting not been used. Of the relevant documents retrieved with Strategy B, 61% were successful solely because of generic posting! (Generic posting also contributed 12 of the Source Documents with Strategy B.)

The argument for generic posting might at first seem to apply to smaller collections or lightly posted terms, but the ratio of Strategy D was effective even for Question 270, which was searched with two descriptors (NOISE and AIRPORTS) that were heavily posted both from indexing and from generic posting.

A distinction should be drawn between the system's Relevance Ratio and the number of non-relevant documents it retrieves. The Relevance Ratios for Strategies A and D were both near 50%, but Strategy A achieved that ratio while retrieving 35 non-relevant; Strategy D retrieved 131. As the system continues to grow, the burden of these non-relevant documents (not the ratio) could become excessive. A tolerable response can be achieved if, as was pointed out earlier, the number of reports desired by a user is known before the search is begun. When only a few reports are wanted, the search can be narrowed by coordinating three or four descriptors instead of just two. Such an approach is needed because the system is not designed to retrieve small, conveniently sized groups of reports on each and every subject: the system has many reports on, say, air traffic control, and it will normally yield a great number (both relevant and non-relevant) for searches within that subject.

Indexing

From the Document Analysis Worksheets inspected in conjunction with the Relevance and Recall tests and from data such as that presented

in Table IV, Jonker found a tendency on the part of indexers to assign the applicable specific terms but to avoid the applicable generic terms. General comments from indexers confirmed this inclination, and they attributed it to the system's mandatory generic posting which, they were subconsciously aware, would afix the generic terms.

The combination of specific terms assigned by indexers and of generic terms automatically posted has, nevertheless, provided an adequate retrieval file for the FAIRS. The present indexing techniques will suffice as long as the "Post Also" feature is retained in the FAIRS, but their omission of generic terms would be a critical weakness if generic posting is discontinued.

Steps should be taken now to assure that the assignment of descriptors, either generic or specific, is determined by the document-at-hand. As an important preliminary change, the guidelines for indexers should be strengthened to emphasize the need for both term-assignments. The tendency can be countered, too, by the editor-supervisor who reviews the indexers' selections for adherence to the guidelines before reports are approved as input to the system.

As a by-product of his daily editing, the supervisor could monitor descriptor assignments by writing hypothetical search questions from the tests of documents just indexed. His searching could be made (in "longhand") from the Document Analysis Worksheets, and retrieval success or failure would provide a rough score for indexers' proficiency (and provide them an incentive).

The 'proficiency score" of indexers in this case assumes the same general meaning as the Recall Ratio as it was developed from the Source Document Questions searched in Jonker's effectiveness test. This day-to-day information about retrieval would be valuable feedback for the system if it were cumulated monthly and coupled with the Relevance data developed from actual searching.

Because indexers must anticipate the user's viewpoint and relate it to the document-at-hand, it was helpful during the contract to have indexing and searching done within proximity of each other at the FAA Library. Jonker indexers gained even more insight into the system's uses from the analysis of Search Question Records that preceded the effectiveness tests. The analysis of that collection of search questions also identified the subject matter most often requested by users (the ten most frequently searched subject areas are listed in Figure 5). To continue these benefits, Jonker suggests that the Search Question Records be reviewed by indexers each month. The Records should be reviewed for other reasons, as is suggested in the next section of this report.

Thesaurus Adequacy

With the addition of the 10,000 technical reports into the system, a total of 403 new descriptors were suggested for addition to the Thesaurus, and 356 of them (Appendix E) were approved by the FAA Project Officer. The new terms were derived primarily from the input side of the system, having come from report indexing, while lesser attention was given to the output side of the system. New terms should, nevertheless, be derived from both sides of the system so that the Thesaurus can communicate between the indexers who put reports into the system and the searchers who take reports out of the system. The search questions used in the study of the system's effectiveness, for example, emphasized the value of several recently established descriptors, such as AIRPORT SURFACE TRAFFIC and CLEAR AIR TURBULENCE. The questions also provided candidate descriptors, such as BIRDS(INGESTION), BIRD STRIKE, SCARE DEVICES, and LAND USE.

To proximate a balance between current literature and future questions, changes in the system's vocabulary should reflect both those influences. Because the users' natural terminology is expressed on the Search Question Records, Jonker believes those Records should be reviewed monthly by the persons responsible for developing the Thesaurus.

The Thesaurus growth from 2,813 descriptors to 3,093 descriptors (about 10%) was drastically lower than the almost-4-fold increase (from 742 terms to 2,813 terms) which occurred from indexing the system's first 5,000 reports. Because deletions will continue to accompany additions, the size of the Thesaurus could stabilize in the vicinity of 3,000 descriptors. Deletions will, however, more critically affect the future size of the Thesaurus. Some statistics about descriptor usage are valuable in understanding that change.

For the first 10,000 reports in the system, indexers used descriptors an average of 29.5 times each, but there was a great deal of variation among their posting densities. The 176 established descriptors that were deleted (Appendix F) had never been used, while AIR TRAFFIC CONTROL SYSTEMS was used for 889 reports. (FEDERAL AVIATION AGENCY was the most-used at 2,262.) The descriptors' median use, a more significant statistic, was determined to be only seven. As shown in Figure 4, the most startling value is the mode use of descriptors at only one! Although the distribution plotted in Figure 4 was prepared before any established descriptors had been deleted, it can readily be argued that the Thesaurus still contains many under-used or unnecessary descriptors; and without generic postings, the situation would be much worse.

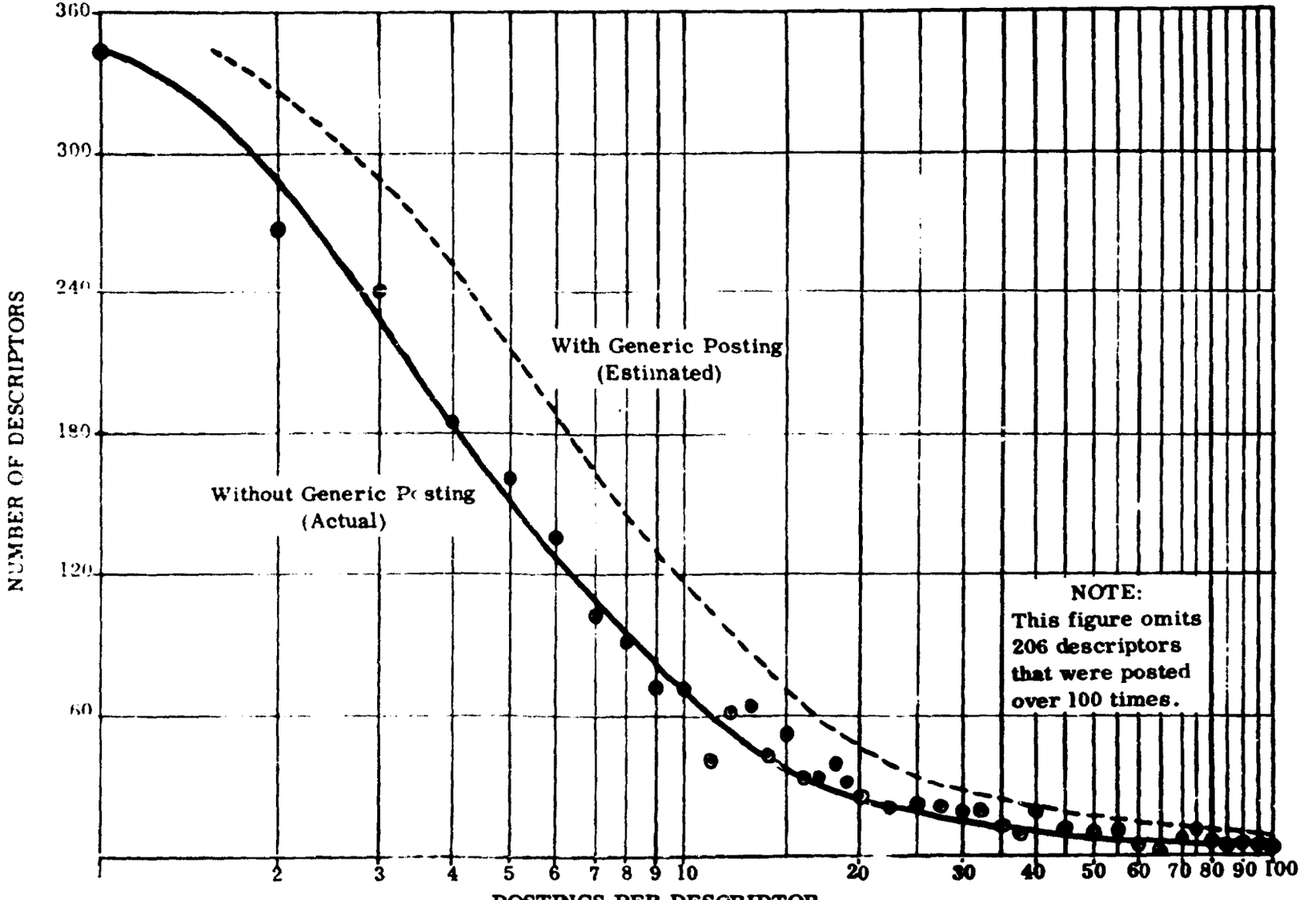


Figure 4 - DISTRIBUTION OF DESCRIPTOR POSTING DENSITIES

As the system grows, some of these descriptors will be used more frequently; nevertheless, each should be evaluated in terms of its posting density before another edition of the Thesaurus is prepared. Such a study of descriptor usage should be conducted to correlate the relationships among three fundamental variables of searching and retrieval in the FAIRS: the posting densities, the number of search terms coordinated, and the number of reports yielded. The benefits anticipated from such a study would be in terms of a more efficient vocabulary (fewer terms and a more economical file) and of a more satisfactory search procedure.

Use of Termatrex

By analyzing the search questions which were imposed on the Termatrex system since it became operational, Jonker has been able to categorize the subjects most often requested (see Figure 5).

Figure 5 - SUBJECT AREAS MOST FREQUENTLY SEARCHED IN THE FAIRS

AIR TRAFFIC CONTROL
AIRCRAFT NOISE AND SONIC BOOMS
AIRPORTS
ELECTRONICS
FAA POLICY
HAZARDS AND SAFETY
METEOROLOGICAL PHENOMENA
NAVIGATIONAL AND LANDING AIDS
RADAR
SUPERSONIC TRANSPORT

As in any information system, the report acquisitions (and report indexing) should reflect the users' interests that are expressed in these 10 categories.

From the same analysis it was found that, during the last year, 24 questions from within the Headquarters were applicable to Termatrex searching although Termatrex was not used; a similar problem surely exists in the Regions. Some of these omissions can be attributed to the newness of the FAIRS, so they should be less frequent in the future. The Agency has, moreover, already devoted some attention to the training of personnel who should use the system.

Because of personnel turnover (if for no other reason), such training is a continuing necessity for the FAIRS. The largest possible population of users should be aware of the kinds of information in the collection and the retrieval tools available to them. The training function applies to all FAIRS installations, but the lack of it would be particularly acute in the field locations, where the system is nearly a year newer than it is at the Headquarters.

As a first step in providing user training, the Agency should consider a basic operating manual that would serve the system's operators, too. Less passive aids, such as standard briefings, training films, special slides, etc., should also be considered.

Report Shelving

One by-product of Jonker's indexing and effectiveness tests was the inadvertent discovery of reports that were already in the collection. Although reports to be indexed were selected by the Information Retrieval Branch, HQ-600, it remained possible for Jonker indexers to recognize 45 duplicate reports (even when reviewed days apart) and to return them to the Project Officer before they had been reprocessed.

Still other duplicates were not detected until after they had already been entered into the system. Of the 10,000 reports indexed, 84 were found to be duplicates after they had been reprocessed. That number is a relatively low percentage of the total processed, but it represents a sizeable processing cost.

Checking incoming materials for duplication is an essential step in any information system and, quite properly, materials at FAA are being checked. The tools available for finding duplicates, however, are far from adequate. In many cases, the incoming document must be physically compared to the ones already shelved, which is more cumbersome and time-consuming than comparisons made within some form of report index.

More importantly, because the reports are shelved in corporate-source order for duplicate checking, they are difficult to retrieve and file for day-to-day searches. It is estimated that half of the time spent on filing and retrieving might be saved if serial number (accession number) order were used for shelving. The user's time is also spent while he waits for reports to be pulled. The conversion of the shelves from corporate source to accession number order must await the development of an adequate tool to replace the existing technique of duplicate checking, such as a book or card catalog organized as an index of report title. The catalog could be prepared as a computer printout from the data now available in punched paper tape.

Medical Reports

The acquisition of medical and non-medical reports should be better coordinated. Medical reports are selected for the system on the basis of their subject matter by the Medical Librarian, while other reports are selected by personnel in the Information Retrieval Branch. Thus, when the subject matter is not distinct (say in Bionics or Physiology), a candidate report could be selected by both groups or by neither. To correct this procedure, the two groups should coordinate the materials that they scan for report acquisition.

Book or card catalogs would have value as retrieval tools for the FAIRS, which now has only a subject searching tool (Termatrex). Their value would be particularly applicable to medical reports, where the author's name is often as important for retrieval as the descriptors for his subject. This trait of medical literature partially explains why so few medical searches were found among the reference questions that were reviewed prior to Jonker's effectiveness tests. None of the ten questions used in the test were on medical subjects.

As another weakness of the FAIRS, medical reports are shelved in an area physically separate from the other reports. The system bears the common burdens of two different files, but because the accession cards are not marked to designate medical reports, the user (or FAA staff member) is not directed to the appropriate file. This inequity could be eliminated by simply adding such a code to the accession cards.

Identifier File Size

The identifier file, now at about 6,700 cards, was increased by 4,000 cards during the project, or about .40 cards per report. That growth rate is only slightly less than the rate of .54 per report which accompanied the first 5,000 reports in the system. If not regulated, the file's size will soon become a problem. (By the time another 10,000 reports are in the system, it could have exceeded 10,000 cards.) Some further explanations should be useful, however, before a means is chosen to control that file.

Because of its nature, the identifier file can logically be expected to continue growing faster than the Thesaurus. For example, the Thesaurus contains about 52 descriptors to cover kinds of aircraft (including the descriptor AIRCRAFT), but it will acquire additional descriptors only as new kinds of aircraft become known. The identifier file, on the other hand, includes hundreds of cards for the names of the aircraft and can be expanded with the names of each new model that is developed. Because these

aircraft models become obsolete or are renamed, moreover, the identifier file always contains information of temporary value. In short, the file is characterized by continual growth and continual obsolescence.

Two basic ways of overcoming those traits of the file might be used at FAA. The first method is to weed out old, existing identifiers. The entire file could be reviewed, say, annually by assessing the value of each identifier. Because proportionately few of the existing identifers are now old enough to be weeded, however, this method would be more applicable in the future. The second basic method is to restrict the number of identifiers presently going into the file. Identifier selection could be limited to important classes such as airplane engines, airplane models, airport names, helicopter models, FAA project names, etc. The desired classes could be specified by a revision in the guidelines for indexers. Of the two methods, the latter is preferable because it is applicable now and because it requires less effort to achieve the same result.

Personnel

About 12,813 man-hours were spent on the project and were allocated to various tasks as shown in Table V.

Table V
ESTIMATED TIME PER PROJECT TASK

TASK	MAN-HOURS		
	Clerical	Professional	Total
Processing Reports			
Indexing		2,651	2,651
Cataloging & Coding	1,495	372	1,867
Editing		930	930
Flexowriter	1,422		1,422
Implementation	529		529
Developing Thesaurus			
Justifying New Terms		241	241
Editing Structures	118	276	394
Preparing Index for Manuals	1,652	26	1,678
Reviewing Legal Memoranda	662	612	1,274
Testing the System's Retrieval	140	423	563
Training	232	393	625
Project Planning	10	629	639
TOTAL:	6,260	6,553	12,813

The processing rates for two key tasks, depicted in Figure 6, show that the project started slowly but finished nearly on schedule. Early slippage on the project was caused by the time devoted to training and by delays in preparation of the intricate program tapes for the Flexowriter processes.

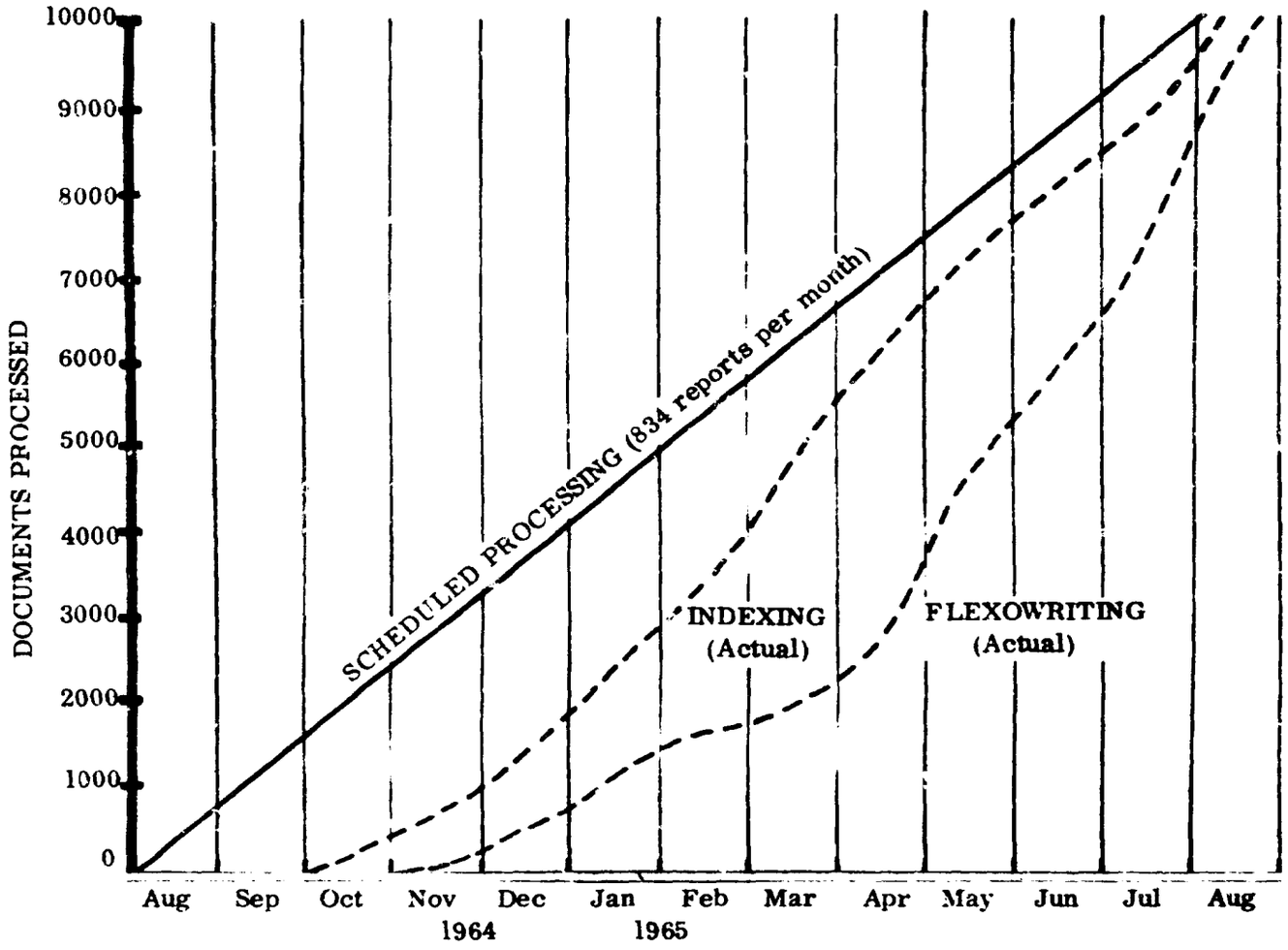


Figure 6 - REPORT PROCESSING RATE DURING THE PROJECT

CONCLUSIONS

It is concluded that:

1. The design and use of the Search Question Record is inadequate. The Record would have more value in bibliographic reference if it displayed a full narrative form of each question and the accession number of reports retrieved for it. To encourage use of the Thesaurus before searching, the record also should display the candidate descriptors that might be used for each question.

2. The future growth of the FAIRS can be guided by two kinds of "feedback information" derived from the system's present operation:

   a. Relevance data (denoting user satisfaction) as it is recorded on the Search Question Records.
   b. Recall data acquired via "Source Document" questions posed by the indexers' supervisor.

3. Precautions are needed to ensure that the indexers' selection of generic descriptors is governed by the document-at-hand and not by the system's automatic generic posting. Their tendency to emphasize the specific descriptors can be countered by training (via the Guidelines for Indexers) and by the source document questions.

4. The future size of the identifier file should be limited by controlling what goes into the file. Weeding the existing identifiers is an impractical way to reduce that file at this time.

5. A new information system such as the FAIRS should provide a means for training its users (and operators) so that they are familiar with the information tools of the system and with the techniques of retrieval. This function, especially important to the field installations, can be satisfied by a training-instructional aid such as an operating manual, training film, etc.

6. Generic posting enhances the system's ability to retrieve relevant reports. The irrelevant reports it also retrieves can be reduced through a search strategy wherein the coordination of two generic descriptors is avoided.

7. The number of seldomly used descriptors in the Thesaurus poses a problem requiring additional study. Those descriptors, an uneconomical segment of the vocabulary, make the search procedure cumbersome.

8. The workload and inaccuracy of acquisitioning new reports would be lessened if the incoming material was compared to an index instead of to the shelf. A book catalog, now feasible with the punched paper tape as computer input, should be organized by report title. Alternate arrangements by corporate source or personal author, although more prone to error, can be considered.

9. Shelving reports in accession number order would improve the general operation of the system, making it more responsive to day-to-day searching. The conversion of the shelves from corporate source order to accession number order must await development of a suitable tool for duplicate checking.

RECOMMENDATIONS

It is recommended that:

1. The Search Question Record, to be used for all search questions, be re-designed as suggested in Figure B-10 to provide more space for the following:

   a. The narrative form of each question.
   b. The candidate descriptors for searching.
   c. The accession numbers of reports that were found to satisfy the user.

2. "Source Document" questions be written daily by the editor-supervisor to check indexers' proficiency and to acquire feedback information about the system's retrieval.

3. The Guidelines for Indexers be revised to encourage indexers to equally emphasize specific and generic descriptors and to restrict their selection of identifiers to only the most important classes.

4. The Agency undertake development of a training-instructional aid for users of the system at the Headquarters and field installations. (An operating manual should be considered a minimum.)

5. Generic posting be continued at the present time. As a distant future consideration, before the index file is converted to automatic data processing, the economics of generic posting should be reconsidered.

6. A special study of descriptor usage be conducted to find an optimum vocabulary size and more economical search procedures for the system.

7. A cost-benefit study be conducted to determine the economic feasibility of using ADP techniques to prepare report catalogs, with the available punched paper tape as computer input. The arrangements to consider for the catalogs are:

   a. By title, for duplicate checking,
   b. By author for retrieval,
   c. By corporate source, for retrieval.

8. Contingent upon the development of the title catalog, the report shelving be converted from corporate source order to accession number order.

9. To avoid inadvertently adding duplicate reports to the system, the scanning of announcements materials be coordinated between the Medical Library and the Information Retrieval Branch.

10. The accession cards for medical reports be marked to reveal the special file location of those reports.

REFERENCES

1. Berninger, D. E. (and others). 1964. Guidelines for Cataloging and Indexing. Jonker Business Machines, Inc., Washington, D. C. (October).

2. Montague, Barbara. 1965. (Private Communication).

3. Department of the Navy, Bureau of Ships. 1964. Project Sharp. SHip Analysis & Retrieval Project: Information Storage and Retrieval System: Evaluation of Indexing Procedures and Retrieval Effectiveness. Washington, D. C. 20360, p. 9. (June).

4. Lancaster, F. W. and Mills, J. 1964. Testing Indexes and Index Language Devices: The ASLIB Cranfield Project. American Documentation, 15: 8 (January).

5. Air Force Materials Lab, Air Force Systems Command. 1964. An Evaluation of Links and Roles used in Information Retrieval. ML-TRD-64-152, p. 67. (July).

6. Montague, Barbara A. 1964. Testing, Comparison, and Evaluation of Recall, Relevance, and Cost of Coordinate Indexing with Links and Roles. Vol. 1, Proceedings of the American Documentation Institute Annual Meeting, October 5-8, pp. 360-361.

7. Taube, Mortimer. 1965. A Note on the Pseudo-Mathematics of Relevance. American Documentation, 16:69-72 (April).

APPENDIX A

Final Report
Contract FA64WA-5186
(Items 4 and 5)

PROCESSING LEGAL MEMORANDA AND CONGRESSIONAL MATERIALS FOR THE LAW LIBRARY

D. Berninger
P. Eiholzer
R. Korenman

Prepared for

FEDERAL AVIATION AGENCY
OFFICE OF GENERAL COUNSEL

by

JONKER BUSINESS MACHINES, INC.
Federal Systems Division
Washington, D. C.

FOREWORD

This report summarizes the work accomplished under Article I, Items 4 and 5 of Contract FA 64WA-5186, which required the processing of legal memoranda and Congressional materials. The report presents some statistics related to the work, and discusses some of the problems encountered during the effort. The report also recommends procedures to be followed in the future.

I. INTRODUCTION

In close coordination with the Law Library, personnel from Jonker Business Machines, Inc. performed several tasks related to Legal Memoranda and Congressional Materials. The major tasks involved were as follows:

Legal Memoranda

- Reviewing of selected memoranda
- Charging and discharging materials from the file
- Collating with memoranda from other collections
- Listing memoranda by subject

Congressional Materials

- Collating by congress and type of material
- Preparing materials for binding
- Reviewing legislative histories
- Acquiring missing materials

II. LEGAL MEMORANDA

Work Accomplished

As the first step toward compiling a complete set of legal memoranda, memoranda from 35 file drawers of General Files were reviewed according to the following criteria:

1. Having permanent, historical, or lasting value.
2. Containing legal precedent.
3. Containing legal research.

During this review, 1,721 folders containing a total of over 100,000 pages were processed and 3,211 memoranda were retained. The 3,211 items, averaging about two pages in length, were temporarily charged from the file systems, microfilmed, and reproduced to facilitate their comparison with memoranda from three other collections.

The other collections contained an additional 4,800 items of which about 1,300 were chronologically merged into the first group to give a complete set of legal memoranda comprising about 4,500 items.

Accession numbers had been assigned to the selected memoranda and listed adjacent to their respective file-system subject for cross-referencing a search of the memoranda.

Time Spent

The reviewing of memoranda required 208 hours by two professional staff members who had subject background in law (one was a law school graduate). These professional personnel and a clerical person spent an additional 182 hours to charge and 84 hours to discharge the memoranda from the files; they spent another 299 hours collating the collections of memoranda. The number list for cross-referencing required 32 hours.

Coordination of the microfilming and reproduction processes with other work absorbed another 90 hours.

Problems Encountered

No serious problems were encountered during this phase of the project; however, two minor problems were encountered. One involved the tedium in charging and discharging memoranda from the files and in collating the 8,000 items of the four collections. The details of these particular tasks required unusual attentiveness for several consecutive workdays. In the future such tasks should be interrupted by a "change of pace;" such a convenience was not possible on this project.

The second problem involved the microfilming and subsequent reproduction of memoranda: more time than anticipated was spent on the coordination of these. That problem is somewhat unique to this project in that unusually critical deadlines had to be met. In one case, for example, the memoranda could not be available until a Friday night, but had to be reproduced and returned by Monday morning.

III. CONGRESSIONAL MATERIALS

Work Accomplished

Congressional materials from the 74th Congress through the 88th Congress were collated by Congress and by type of material: Hearings, Reports, Documents, and Prints. Within each type, the materials were arranged by their source (House, Senate, or Joint) and alphabetized by title. These materials were arranged in shelves where 130 items were marked for binding; 150 legislative histories were reviewed and missing items that were available elsewhere within the Federal Aviation Agency were acquired.

Duplicate copies of these materials were similarly arranged on the library shelves.

Time Spent

A total of 379 man-hours were spent arranging congressional materials. About 300 hours were spent actually collating materials; the remainder was spent preparing materials for the binder, shelving duplicates, reviewing legislative histories, and acquiring missing items.

Problems Encountered

The only notable problem encountered with the congressional materials was that they could be collated only by a person familiar with their types. That person had to recognize the obscure differences among, for example, Reports, Documents, and Prints.

The specialized nature of these congressional materials restricted the assignment of other personnel to that task although their time was occasionally available.

IV. RECOMMENDATIONS

As a result of the work done on Items 4 and 5 of Contract FA 64WA-5786, a series of general recommendations can be made to materially assist the General Counsel's Office of FAA in the retrieval of legal documentation necessary to their work.

At this point in time and with little knowledge of user requirements, however, the whole panorama of an Information Retrieval System and its intra-relationships with the communication language and retrieval hardware cannot be specified in great detail. Nor can one state precisely, now, the type and depth of indexing (intellectual analysis of substance of the documents) required for legal documents. All of these variables inter-act with one another and the realities of FAA's economics.

In spite of the restrictions mentioned above, it is recommended that the Federal Aviation Agency pursue an information system for legal information that embodies the concept of centralized-processing but decentralized-operation, comparable to how the concept is embodied in the Federal Aviation Information Retrieval System (FAIRS) now operating at FAA Headquarters.

As the first step toward implementing that concept, it is recommended that a "feasibility experiment" be conducted to explore such variables as: user requirements, language problems inherent in the system, indexing problems, and the cost

trade-offs possible. Such an experiment could be undertaken either by FAA or by an outside contractor (in either case, FAA would be heavily involved), but should include and follow the protocol outlined below:

1. A sufficient sample of existing FAA legal opinions and legal memoranda should be indexed by their substantive retrieval concepts, utilizing accepted legal terms and additional factual terms as applicable, to determine generalized requirements of a thesaurus of legal terminology of FAA.

   a. The sample should be materials from latter years, chosen at least partially from those among the memoranda chronologically collated during the task just completed.

   b. This sample should be compatible with Regional needs.

   c. The sample should include material topics of Procurement Law, general legal services, litigation, airports, regulations, and enforcement.

   d. The size of the sample will, of course, be a direct function of economics.

2. The thesaurus of terms generated from indexing opinions and memoranda should be extensively edited and criticized by FAA staff attorneys at Headquarters and at Regional Offices, who have practical knowledge of legal documentation and the requirements to be imposed upon its retrieval.

   a. The thesaurus should not only be examined but also tested by competent General Counsel attorneys for its potential retrieval efficiency.

   b. This editing, reviewing, and testing should, in turn, general suitable generic relationships and cross-references.

   c. A revised thesaurus, incorporating the aforementioned term "structures" should be developed as a good first cut of a firm efficient vocabulary control over future indexing.

   d. It must be remembered that this latter thesaurus will be only a "good first cut." It should always

remain open-ended (subject to change and modification, but only under rigidly controlled conditions).

e. Further, this thesaurus, analyzed in conjunction with the indexed documentation, will teach many lessons about the approach and depth of indexing required.

3. The legal opinions and legal memoranda indexed originally in the sample should be re-indexed to correct deficiencies indicated in the procedure above.

4. The revised indexing terminology from the sample should be converted into information retrieval hardware.

5. Depending upon the success and economic trade-offs of the above effort, we conditionally recommend that Congressional materials be considered for indexing by their "administrative handles," such as Titles, Types of publication, Publication numbers. An "administration legal thesaurus" would then be generated and follow through a similar set of steps indicated in 2 above.

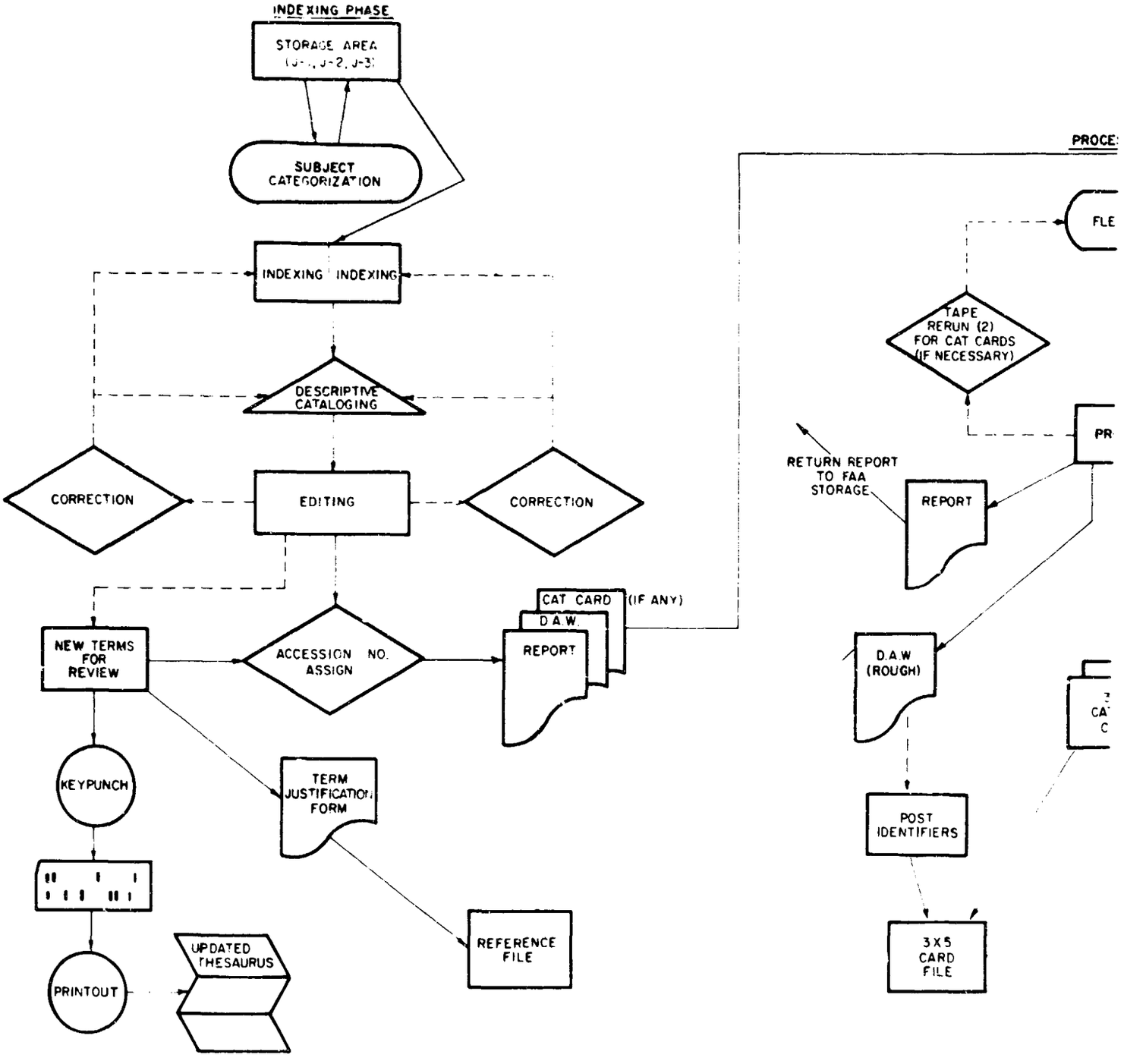
6. Criteria should be established so that each function and component of the experiment can be evaluated. These criteria are a prerequisite to realistic and intelligent trade-offs. Appropriate decisions (and implementation of these) can then be made on overall system approach, hardware, procedures and timing; and on back logs of legal opinions, legal memoranda and Congressional materials.

7. The experiment should explore coordination problems with Regional Offices (and their part in the program), updating procedures and other areas not immediately obvious and critical here.

APPENDIX B

PROCEDURES AND DOCUMENTS OF THE SYSTEM

LIST OF ILLUSTRATIONS


INDEXING PHASE
STORAGE AREA
SUBJECT CATEGORIZATION
INDEXING
INDEXING
DESCRIPTIVE CATALOGING
CORRECTION
EDITING
CORRECTION
NEW TERMS FOR REVIEW
ACCESSION NO. ASSIGN
CAT CARD
D.A.W.
REPORT
(IF ANY)
KEYPUNCH
TERM JUSTIFICATION FORM
PRINTOUT
UPDATED THESAURUS
REFERENCE FILE
PROCE
FLE
TAPE RERUN (2) FOR CAT CARDS (IF NECESSARY)
PR
RETURN REPORT TO FAA STORAGE
REPORT
D.A.W. (ROUGH)
POST IDENTIFIERS
3X5 CARD FILE

A.

PREPARED BY:

JONKER BUSINESS MACHINES, INC

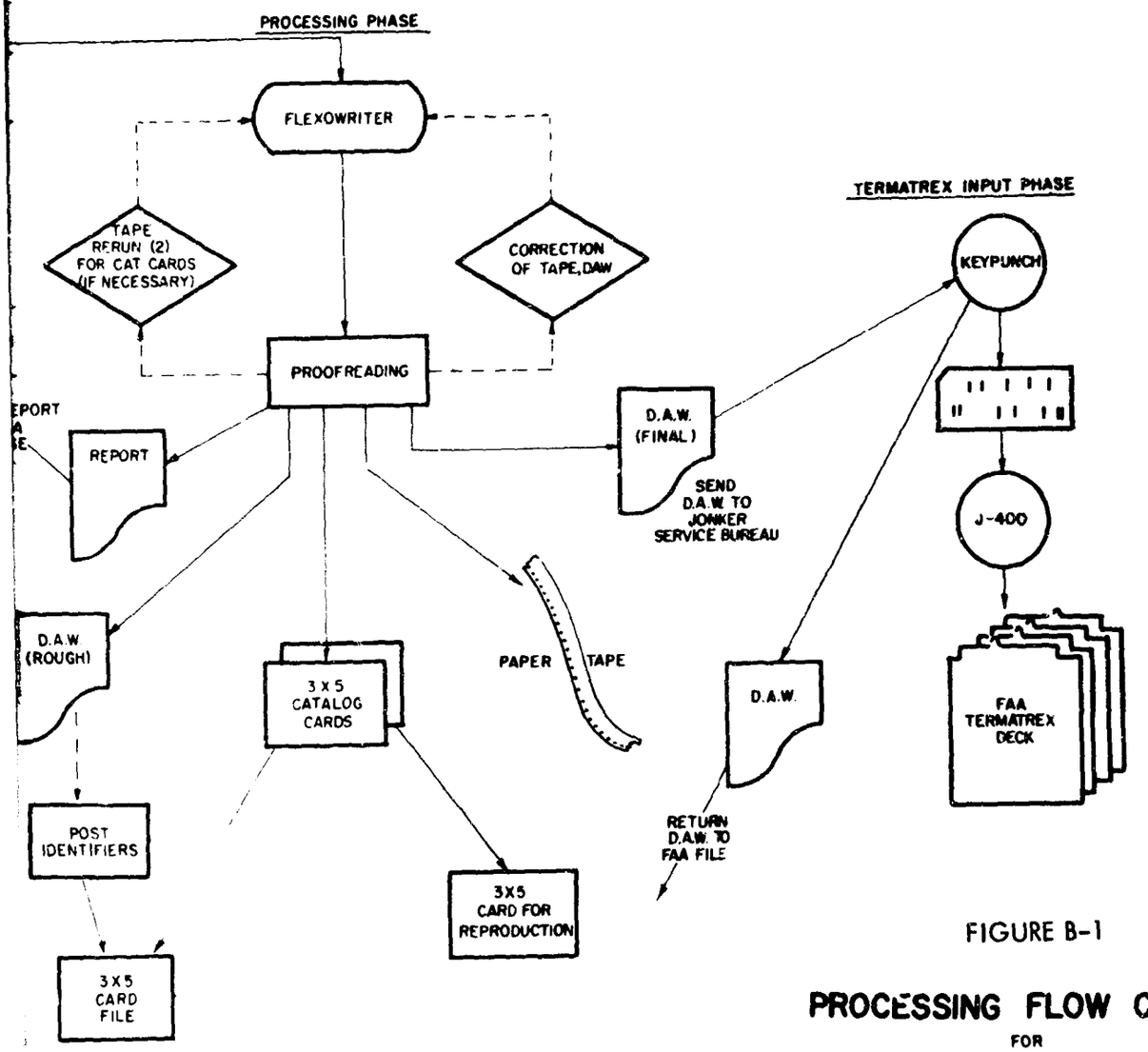


FIGURE B-1

PROCESSING FLOW CHART

FOR

INVESTIGATION INTO THE RETRIEVAL, INDEXING AND SEARCHING SYSTEM

B.

Figure B-2

DOCUMENT ANALYSIS WORKSHEET

7214	AD-401 276		U

Conductron Corp., Ann Arbor, Mich.

NEW VOR COUNTERPOISE SYSTEM FOR REDUCTION OF SITING ERRORS. Final Report. Project 115-42D.

J. R. Smith (and others)

Jan 64	65p.	refs.
RD-64-47	FA-WA-4665	

General Distribution.

IDENTIFIERS

Counterpoise

*	CODES	DESCRIPTORS	*	CODES	DESCRIPTORS
*	5465.00	VOR (VHF omnidirectional radio range)			
	2802.00	Loop antennas			
*	0298.00	Antenna radiation patterns			
	4414.00	Scattering			
	1657.00	Errors			
	0294.00	Antenna configurations			
	1495.00	Electric fields			
	4551.25	Site selection			
	1744.00	Federal Aviation Agency			

FAA Form 3328 (1-69) USE PREVIOUS EDITION (1780)

Figure B-3
SPECIFICATIONS OF DOCUMENT ANALYSIS WORKSHEET

Bibliographic Field	ADP Identification Code	Size of Field (Digits)
Accession Number	P1 1	5
AD Number	2	10
Microfilm Identification Number	3	11
Security Classification	4	1
Source	C1	240
Title	C2	240
Authors	C3	60
Date	C4	10
Pagination	C5	6
Report Series Number	C6	30
FAA Contract Number	C7	12
Limitations	C8	300
(First) Identifier	I1	60
(Second) Identifier	I2	60
Etc.	Etc.	Etc.
(First) Descriptor	D1	
Asterisk		1
Code		7
Descriptor		76
(Second) Descriptor	D2	
Etc.	Etc.	

Figure B-4

TERM JUSTIFICATION FORM

1) Term: LOW TEMPERATURE RESEARCH	11020
2) Code Number: 2815.50	Accession number of source document

3) Definition or explanation of term:
Below ambient temperature but above 100°K, the maximum for the cryogenic range.

Source of definition:

Relationship of suggested term to existing FAA terminology:		Relationship of suggested term to existing ASTIA terminology:	
4) Descriptor group: (Research Fields)		Descriptor group:	
5) Includes:		Includes:	
6) Specific to: SCIENTIFIC RESEARCH		Specific to:	
7) Generic to:		Generic to:	
8) ALSO SEE: CRYOGENICS COLD WEATHER TESTS		ALSO SEE:	

Indexer's comment: The term is included in the ASTIA Supplement, and is needed for indexing where CRYOGENICS (already a descriptor) does not apply. As a precedent, the Thesaurus already has HIGH-TEMPERATURE RESEARCH.

Identifier file check:	Other documents with the term:
No card	

Disposition by Review Committee:

Approved, March 24, 1965

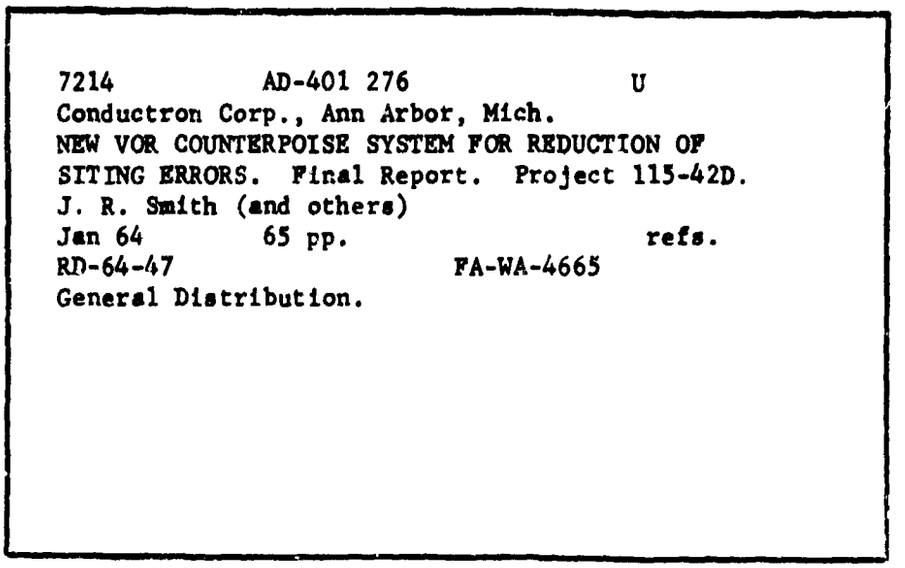


Figure B-5 - SAMPLE CATALOG CARD

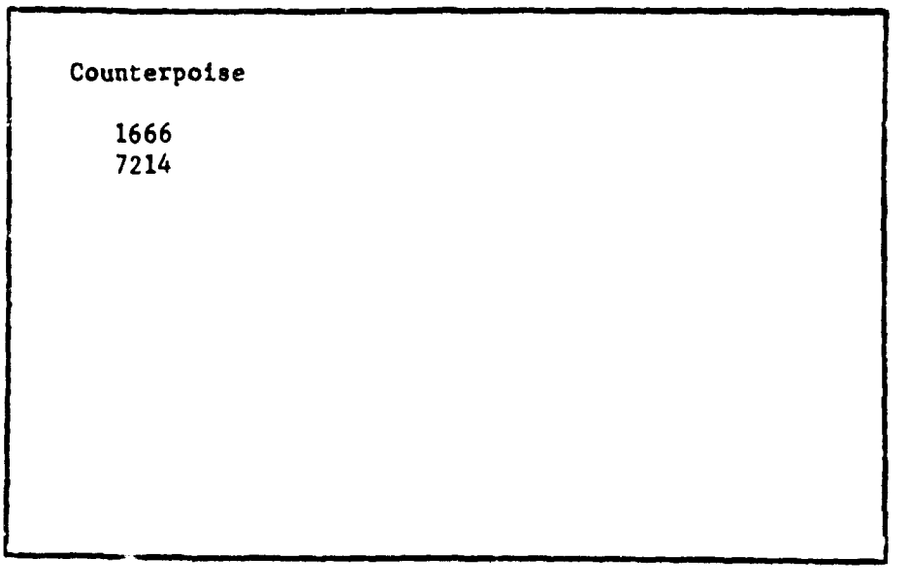
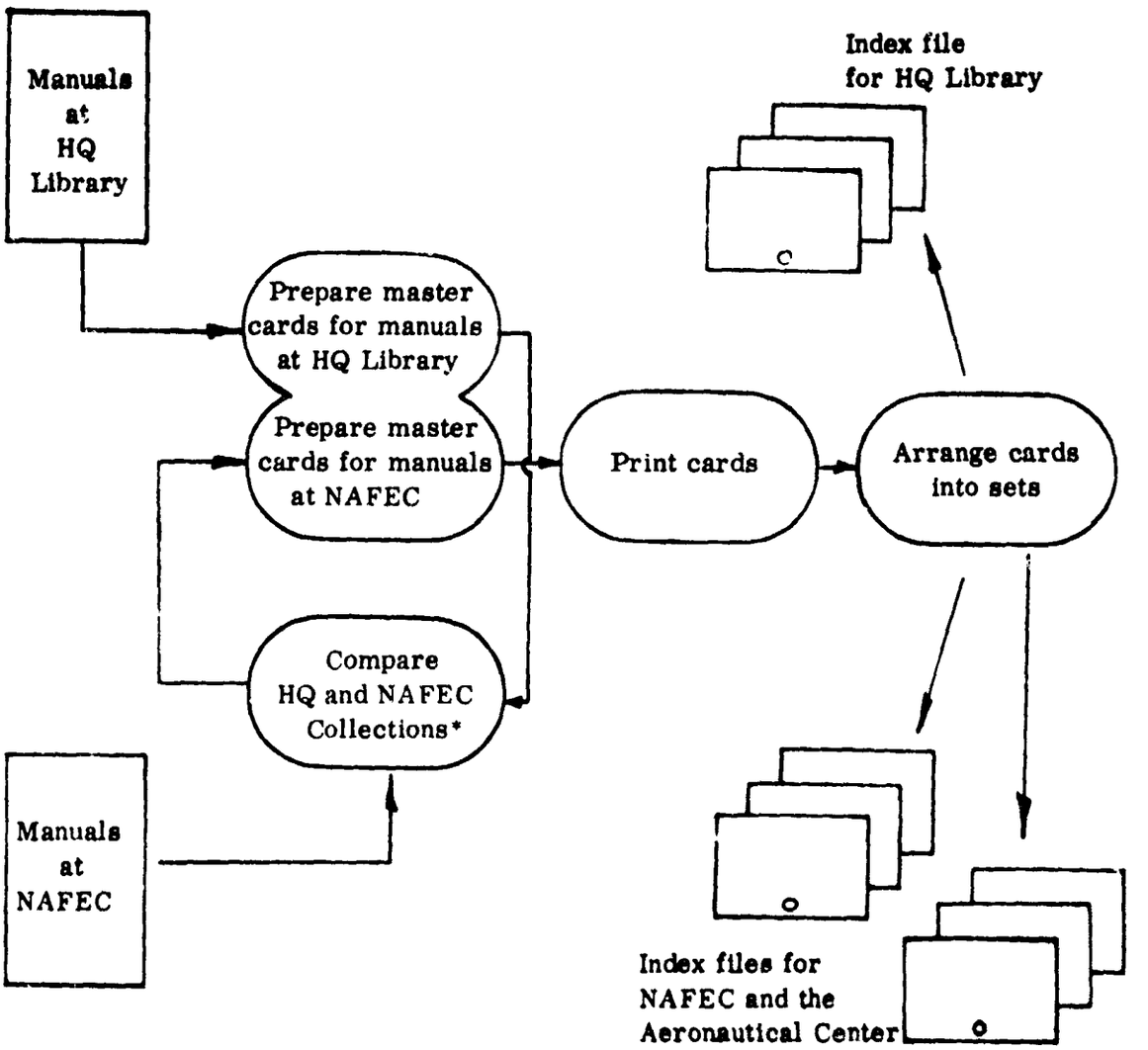


Figure B-6 - SAMPLE IDENTIFIER CARD

Figure B-7

PROCEDURE FOR PREPARING INDEX FILES
FOR INSTRUCTION BOOKS AND MANUALS



*In this step of the procedure, duplicate manuals were screened and location codes were added to the master cards.

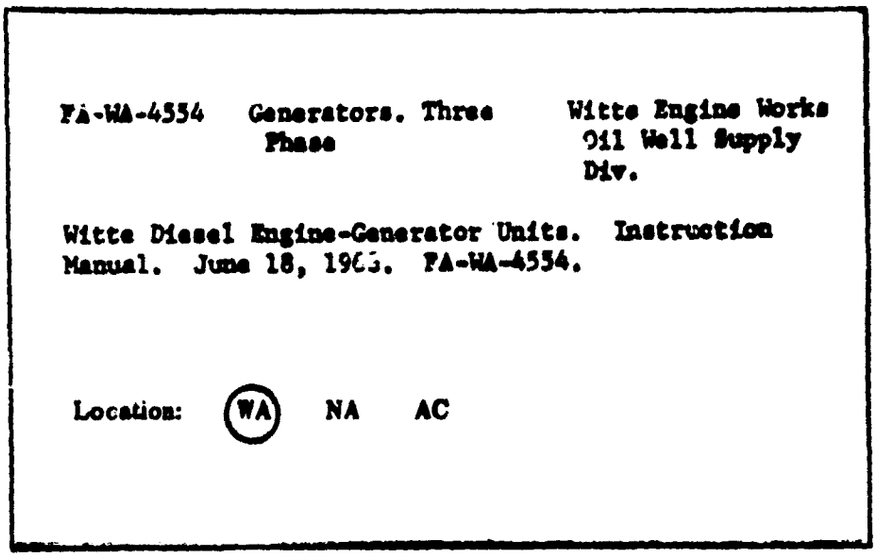


Figure B-8
SAMPLE INDEX CARD FOR INSTRUCTION MANUALS

Figure B-9 - SAMPLE SEARCH QUESTION RECORD

IDENTIFICATION

Search No.	Searcher	Requestor (Name, address, telephone no.)

Date and Time of Request	Date and Time Completed	Total Staff Time	Time Coverage Desired	Deadline

Complete Search Question (Narrative form, specifying all aspects included or excluded):

Sources Checked:

Results and Comments (Continue on reverse side if necessary):

SEARCH

DESCRIPTORS USED IN SEARCHING (Termatrex cards)

Primary Question	1st Sub-Question	2nd Sub-Question

IDENTIFIERS USED IN SEARCHING

RESULTS

Total Number of References Recalled		Total Number of References Recalled		Total Number of References Recalled	
Number of Abstracts:		Number of Abstracts:		Number of Abstracts:	
Judged		Judged		Judged	
Relevant		Relevant		Relevant	
Nonrelevant		Nonrelevant		Nonrelevant	
Number of Reports:		Number of Reports:		Number of Reports:	
Judged		Judged		Judged	
Relevant		Relevant		Relevant	
Nonrelevant		Nonrelevant		Nonrelevant	

FAA Form 2712 (12-66) OBSOLETE PREVIOUS EDITION

Figure B-10
REVISED SEARCH QUESTION RECORD

IDENTIFICATION

Search No.	Searcher:	Requestor (Name, Address, Telephone No.):		
Date and Time of Request:	Deadline:	Number of References Desired:	Date and Time Completed:	Total Staff Time:

Complete Search Question (Narrative form, specifying what is to be included or excluded):

Sources Checked:

RESULTS

Comments:

References Retrieved (Continue on reverse side if necessary):

SEARCH

Applicable Descriptors	Applicable Identifiers

RELEVANCE DATA

Total Number of References Recalled	Number of Abstracts		Number of Reports	
	Judged		Judged	
	Relevant		Relevant	
	Non-Relevant		Non-Relevant	

APPENDIX C

A PLAN FOR TESTING THE RETRIEVAL INDEXING AND SEARCHING SYSTEM AT THE FEDERAL AVIATION AGENCY

D. Berninger
P. Eiholzer
R. Korenman

Prepared for

FEDERAL AVIATION AGENCY
OFFICE OF HEADQUARTERS OPERATIONS

By

JONKER BUSINESS MACHINES, INC.
Federal Systems Division
Washington, D. C.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

PART I

Contractual Obligations

This paper sets forth the details of the test methodology that JONKER Business Machines, Inc. will undertake to comply with the obligations of Contract FA 64-WA-5186: Investigation into the Retrieval Indexing and Searching System. An excerpt of that contract's specifications appears below.*

> "A testing program shall be developed and carried out to test the effectiveness of the document retrieval system (Termatrex) in terms of its recall power (i.e., what proportion of pertinent documents in the system are retrieved in response to a request?) and relevance power (how much "noise"?). The test of the effectiveness of the FAA system, in terms of recall and relevance, shall provide information on:
>
> > The adequacy of the present depth and specificity of indexing, any weakness of the present Thesaurus as a searching tool, the efficacy of generic posting, and optimum search procedure.
>
> "The testing program developed shall be subject to final review and approval by the Project Officer."

The FAA Information System

The Federal Aviation Information Retrieval System (FAIRS) is located in Washington, D. C., where it serves users who have a diversity of needs for technical information. Through a cooperative arrangement embodying centralized processing/decentralized operation, the Agency has made its information available to other users at its remote Regional Offices.

When the FAIRS is tested for retrieval effectiveness, it will have been in operation for about a year and will comprise a collection of 10,000 technical reports covering the gamut of science and technology related to aviation. These documents, numbered and filed serially, have been prepared for retrieval by coordinate indexing from a controlled thesaurus of nearly 3,200 descriptors;[1] an average of 9 descriptors have been assigned to each report.

The major retrieval device for the FAIRS is a manually operated, browseable Termatrex system. A search question is answered with Termatrex by superimposing the applicable cards (one for each descriptor) over a light

*From page 2 of the Negotiated Contract, FA 64-WA-5186.

source, then reading the report numbers that are yielded.

Some other features of the FAIRS have special bearing on the test environment.

1. At the present time, a large indexing project is underway. This on-going project is, in itself, a test-bed for hypotheses and theories that come from the experimental tests. For example, indexing can be redirected to levels of more (or less) exhaustivity or more (or less) specificity.

2. The Thesaurus of FAA Descriptors, used for indexing and searching, is continually being updated and developed. Changing its structures, expanding its scope, or altering its format remain feasible.

3. Within the Thesaurus, moreover, the relationship among generic-specific descriptors is used for a mandatory "generic posting" during Termatrex card drilling. That is, the card for a generic term is drilled when any of that term's specific terms have been selected for indexing. This feature of the system's input is to be studied during the tests so that its merit can be decided.

4. Indexing and searching are conducted within proximity of each other in the FAA Library. The convenient interface between these two functions facilitates the investigation of search strategies and user acceptance, among others.

5. A reference file has been maintained during the past several years to contain the actual search questions that have been asked of the system. Those records will be useful in providing the names of FAA employees who might participate in the tests. Examination of that file will also reveal how frequently the system is used and what subject matter its report collection is expected to provide.

PART II

Experimental Testing

In recent years, the number of systems and devices for storing and retrieving technical information has been growing apace with the expanding volume of published information--a common biproduct of our proliferating research and development activity. But in a society so conscious of its rank in the world's technology, demands for more efficiency are being levied against the people who manage that technical literature.

While in some instances these demands have been belatedly imposed, in almost all instances they have been difficult to satisfy. For one reason, the Laws of Vested Interests prevent "inferior" systems from being exposed. Another reason lies with confusing intricacies of testing any information system--a confusion that even the experts have not settled.[4]

From the very beginning of the era-of-search-for-the-efficient-system, in 1953, M. Taube hoped that "further research by ourselves and others will lead not only to tests of consumer satisfaction with various systems, but also to a more systematic presentation of the interval criteria of evaluation."[2]

Taube's hopes, however, were not fulfilled. "Further research" continued on a host of system attributes, usually expressed as some form of cost, speed, volume, and reliability, but the tests were often conducted without controlled variables and without standardized techniques.

Ten years later, R. R. Shaw assessed the state of affairs in bitter words. "It has yet to be demonstrated that those who have been crying havoc and calling for vast expenditures have anything to offer that will currently increase the effectiveness of our information retrieval services."[3]

On the matter of testing, Shaw called for an end to "claims for whatever system is being advocated, on the basis of facts not given and by comparison with the worst alternatives."

Aware of the "articulate proponents for different systems and of the general interest in IR systems" in 1959, the National Science Foundation sponsored a study that produced the first accumulation of data from an experimental test involving what they called a genuine scientific method.[5] Theirs was a comparative study of the efficiency of four different systems.

As partial financial support, the Foundation granted $159,200 to Western Reserve University.

Another grant of $16,700 went to the Association of Special Libraries and Information Bureaus (ASLIB) for what has become known as the Cranfield Research Project. This latter grant provided for a separate analysis of two of the four systems, which was also published separately in one of the most detailed reports yet to be written on the subject.[6]

Relevance and Recall

In the Cranfield study, two systems were subjected to the same questions, with each searching among documents that were common to their collections. The efficiency of each was measured according to how well it retrieved relevant documents and how well it avoided non-relevant documents. The criteria for comparison, then, were two variables names Relevance Ratio and Recall Ratio.

The basic ingredients for these two ratios are illustrated in the 2 x 2 contingency table below; for consistency, the symbols expressed in the table are the same as those used for the Cranfield study.

Figure C-1 - RELEVANCE AND RECALL CONTINGENCY TABLE

		RETRIEVAL (+)	RETRIEVAL (-)	
RELEVANCE	(+)	Relevant, Retrieved (R)	Relevant, Not Retrieved	Σ = Total Relevant (C)
	(-)	Not Relevant, Retrieved	Not Relevant, Not Retrieved	
		Σ = Total Retrieved (L)		Σ = Size of Collection (N)

From the table, relevance ratio can be expressed as follows:

$$\text{Relevance ratio} = 100 \times \frac{R}{L}$$

Where R is the number of relevant documents retrieved for a search question, while L is the total number of documents retrieved for that question.

Recall ratio can be expressed as:

$$\text{Recall ratio} = 100 \times \frac{R}{C}$$

Where R, again, is the number of relevant documents retrieved for a search question and C is the total number of documents in the collection that have an agreed standard of relevance.

Although Cranfield's Relevance and Recall Ratio's were only 2 of at least 10 other measures developed during the era,[7] they were given an attentive reception of both praise and criticism by Documentalists. One caustic critic predicted an early death for these test criteria and speculated that their use would cause "many current studies to be looked upon--in the course of history--as comparable to the epicycles of the 14th century."[8]

Ironically, the zealous search for a scientific method for testing the performance of IR systems led to the criticisms, for it has been the non-scientific aspects of those studies which have drawn the critics' fire. Their remarks have been lured primarily against those proponents who attribute too much validity to the criteria of relevance and recall, especially investigators who fail to recognize the subjective and non-mathematical nature of the two entities.

At the heart of the controversy has been what Cranfield spoke of as an "agreed standard of relevance." Relevance was determined by subject specialists who reviewed not only every document that the system retrieved, but also those the system did not retrieve (over 100,000 individual assessments!). These judges used a simple standard to gauge relevance: was the report as good as the "source" document from which the search question was originally inspired?

The flaw in judging relevance, say the critics, is that judges cannot possibly determine a report's relevance to an information need, which is to say that "non-users" cannot allow for the difference between an asserted

need (a written statement of request) and a real need. Real needs can be measured only indirectly, by the user they say, and then with great uncertainty.

The truth of the matter is that no one knows the correlation between a request and a need. Needs are seldom clear and are rarely stable; the same may surely be said about requests. They are all victims of time and circumstances. It should be recognized, then, that a successful information system must allow for a user's change-of-heart. (This argument, some say, is a strong one for browseable retrieval systems, such as Termatrex.)

A Decision

Despite the controversy about testing information retrieval systems (which could last another decade), a decision has been made to use the subjective Relevance and Recall Ratios in the present tests. That choice is not merely to satisfy the contractual obligations (which call for a testing program in terms of "Recall power" and "Relevance Power "), but because relevance and recall are believed useful in assessing the internal workings of an information system. A proper realm for relevance and recall in the FAIRS is in drawing attention to the intellectual aspects of indexing, the adequacy of a thesaurus, and the strategies for searching. They should provide information for those who are trying to re-engineer and improve the operation of the system.

PART III

The Proposed Test

This section of the paper presents the plan for conducting an experimental test of the Federal Aviation Information Retrieval System. In brief, the test will evaluate how well the system retrieves reports that are relevant to search questions. The procedure of the test is to search the entire 10,000-document collection with questions that will be randomly selected from those previously submitted by FAA personnel for actual searches.

It is being proposed that these same subject specialists judge the reports that are retrieved for relevance to their particular search question. When the reports have been assessed, the performance of the system will be stated in terms of its Relevance Ratio and Recall Ratio, while further investigations will seek the deficiencies of the system for 1) retrieving non-relevant documents and 2) not retrieving all the relevant documents. As part of the study, recommendations for eliminating these system deficiencies will be made.

The test procedure, illustrated on the next page, is discussed in greater detail in the paragraphs that follow.

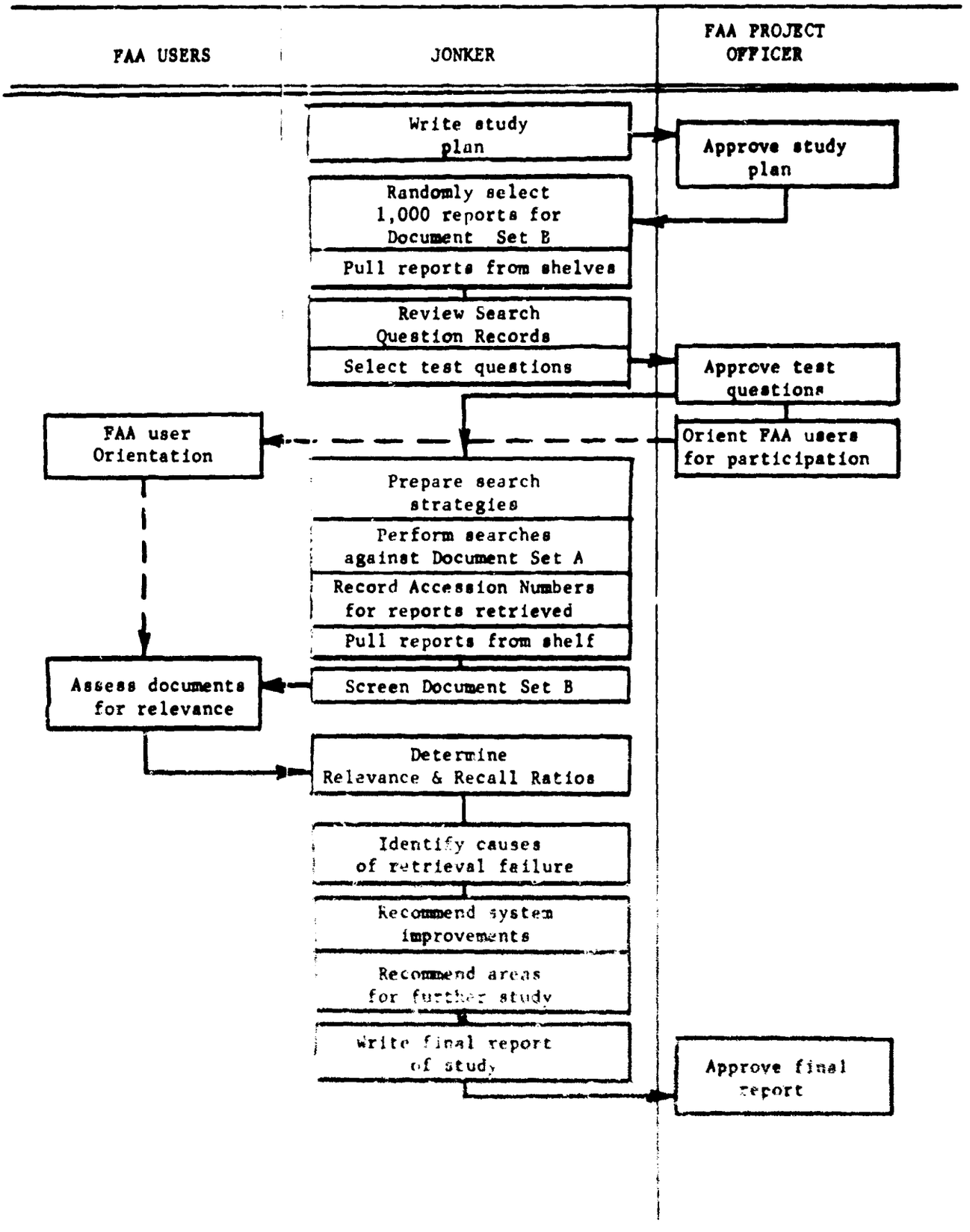
Documents for the Study

The entire FAIRS collection of 10,000 technical reports, which, for convenience will be referred to as Document Set A, will be searched during the tests. It is estimated that Document Set A might yield 30 reports--on the average--for each question imposed against it. Every one of those reports will be judged for its relevance to the respective questions. (These assessments, needed to derive the system's Relevance Ratio, should require about one hour per question.)

Although the proposed test procedure calls for an assessment of every document that is retrieved by searching, it does not require that the entire report collection be judged to identify relevant reports that were missed in searching. The quantity of relevant reports that are missed by the system must be measured in order to derive the Recall Ratio, but to judge every document in the collection against each question is hardly a practical method. To assess each of the 10,000 documents could easily absorb 200 man-hours per question! A tactful limit on that burden to professional people should be no more than 8 man-hours per question. What is

Figure C-2

PROCEDURE FOR EFFECTIVENESS STUDY



equally distressing under such a procedure is that most of that effort would be non-productive. A few words of explanation here will help.

We know that the information system at FAA is specifically designed to satisfy the needs in aviation, and the existence of the FAIRS is justified--in part--by the lack of another information system in the Federal Government devoted to that specialty: others offer indexing and vocabularies that are too general to fit the Agency's needs. The Defense Documentation Center, for example, currently categorizes its reports into 22 fields of which one is "Aviation;" NASA uses 34 categories, including one for "Aircraft." The rest of their collections are allied to many fields that are neither aviation nor aircraft.

We might quickly conclude from these comparisons that the information in the FAIRS is specialized, whereas information in the others is not. Against one frame of reference, that supposition is valid; yet within "aviation" (to change the frame of reference), there exists a great diversity of subjects, such as Air Traffic Control, Display Systems, Weather Forecasting, Navigational Aids, Airport Management, Supersonic Transports, Hazards and Safety, Pilot Training, and Aerodynamics. With a little effort, the list of subjects strongly related to aviation could be lengthened to show clearly that the FAA collection must satisfy a variety of specialized needs within a specialized field. The FAA collection of reports can be considered specialized only if viewed from without, while general if viewed from within.

That anomoly has particular bearing at the moment, because it has prompted us to make a "ballpark estimate" about the number of reports (50) that are likely to be retrieved for any one question. From our experience with the system, we are confident in speculating that for any single information need, for a question imposed upon the system, at least 75% of the reports in the collection are not applicable. Reversing the mathematics makes more sense: for any given question, the collection could not reasonably yield 2,500 relevant reports.

During the conduct of the test, as in "real" searching, it is important to avoid burdening professional men with the entire shelf of reports when we know well ahead of time that only a handful of them could possibly be relevant to his need. By practical necessity, the proposed plan intends to reduce that imposition and to do it simply by reducing the number of (non-retrieved) reports that must be judged.

One early consideration was to assess all the reports that occurred in a set of only 100 randomly chosen documents, but that sample was too small; it would not contain enough reports relevant to any question, thus

failing to provide sufficient statistical data. To collect ample data for the system's Recall Ratio, a 10% sample of 1,000 documents is more appropriate, but as much as 20 hours per question could be required to assess them--an effort again too burdensome. To reach a satisfactory workload without destroying the data base for the tests, it is being proposed that the 10% sample still be used, but that only a portion of its reports be judged for each question: the 1,000-document sample (Document Set B)* will be "screened" to eliminate irrelevant reports.

Screening does not involve direct human judgment of documents as it usually implies, but will be done by selecting descriptors from the Thesaurus for each question. The applicable descriptors will, in combination, define the scope of a given question's subject. (As a rule of thumb, when there is doubt about the applicability of a term, that term will be added to the list.) The reports that will be submitted for relevance assessments for the given question will be those reports that have any one of the chosen descriptors. Reports without even one will be assumed to be irrelevant. An example will help illustrate this screening technique.

Suppose the question-at-hand sought information on the "public reaction to sonic boom and aircraft noise." A cursory review of the Thesaurus reveals at least 11 descriptors that might be related to the subject of that question. The descriptors and their respective posting densities are listed in Figure C-3.

The total posting density of 1060 should be doubled to accomodate the effects of generic postings; and of that new total, about 212 postings (10% of 2,120) would likely appear within the randomly chosen technical reports of Document Set B.

Figure C-3 - SAMPLE POSTING DENSITIES

Descriptor	Posting Density
AIRPLANE ENGINE NOISE	16
AIRPLANE NOISE	64
SONIC BOOM	69
ENGINE NOISE	7
NOISE	276
JET PLANE NOISE	63
REDUCTION	120
SUPPRESSORS (ACOUSTIC)	40
JET PLANES	189
JET TRANSPORT PLANES	165
JET ENGINES	51
TOTAL	1060

So if this were an actual search question and if the list of applicable descriptors were complete, the 212 reports from Document Set B would be submitted to the FAA staff member for his relevance assessments, along with the 50 reports that would be retrieved from Document Set A.

Questions for the Study

Ten search questions will be randomly selected from the actual, past questions that have been recorded on the Search Question Records (FAA Form 2712) and which are retained in the files of the Information Retrieval Branch. As the first step in selecting test questions, the Records have been reviewed; the subjects of 192 candidate questions are listed in Figure C-4 at the end of this Appendix. For a question from that list to be approved for the test, its subject must have remained of current value and interest to the respective user. A question would be discarded, too, if its "author" were unwilling to participate in the tests.

Searching

The key concepts in each of the 10 test questions that are selected will be identified by a list of descriptors, from those used for "screening" within Document Set B. For each question, four different search strategies will then be developed and consistently used, regardless of how the searches were previously made by the FAA Library staff. These strategies will be designed to control the effects of generic posting, thus permitting the adequacy of the Thesaurus and the indexing techniques to be studied.

Searching during the tests will be done manually on the Termatrex system, and the accession numbers of reports that are retrieved for each question will be recorded so that the hard-copy reports can be pulled from the Library shelves and loaned to the FAA participant.

Relevance Judgments

The entire text of each report will be reviewed for its relevance or non-relevance to the respective search question. The standard for gauging relevance should be:

> "Does the report provide information which has direct bearing on the search question?"

Notations of relevance (yes) or non-relevance (no) will be made by the judges onto the accession number lists that will have been developed during searching.

Relevance assessments for the total of about 2,600 technical reports should require about 52 man-hours, or about 5 hours per question. That estimate is based on:

500 technical reports from Document Set A, at 50 reports retrieved for each of 10 search questions.

2,100 technical reports from Document Set B, at 210 reports screened for each of 10 questions.

Relevance and Recall Ratios

Relevance and Recall Ratios will be calculated for each test question, and then for the system by cumulating the individual results. These over-all ratios provide a basis for comparing the FAIRS to other systems, to the same ratios developed during other experimental tests.

The tabulations used throughout the tests will have facilitated these calculations, because they will have denoted:

Relevant documents retrieved
Relevant documents not retrieved
Non-Relevant documents retrieved

Reasons for Failure

Since these tabulations have identified the system's success and failure about specific technical reports, it shall be possible to determine the causes of retrieval failure by examining the documents and their Document Analysis Worksheets. Document inspection is a key step in exploring the internal workings of the system, and it should do much to measure the effects of generic posting, the adequacy of the Thesaurus, the strategy for searching, and the techniques of indexing. To reflect on these major areas of the system's operation, the "causes of failure" have been so organized in tentative checklists:*

* These checklists are not final. In fact, they will be generated after the documents have been examined--not before--so that an analytical view can prevail.

RELEVANT BUT NOT RETRIEVED

INDEXING

- Concepts omitted
- Concepts indexed too generically
- Concepts indexed too specifically
- Clerical errors in coding

SEARCHING

- Specificity
- Exhaustivity

THESAURUS

- More than one descriptor for the concept
- Inadequate references to comparable concepts
- No descriptor for the concept
- Restriction imposed by Descriptor Group
- Generic posting

NON-RELEVANT BUT RETRIEVED

INDEXING

- Too exhaustive
- Too specific

SEARCHING

- Concepts searched but only implied by question
- Concept too generic
- Concept omitted from search strategy
- Improper coordination of search terms

THESAURUS

- Concept too generic (from generic posting)
- Term too abstract
- Specific term lacking
- Intermediate term lacking

Documentation

The results of the study will be documented in a special section of the final report and will be in a format suitable to compare the topics covered by the Cranfield Research Project[6] and by Atherton's reporting standards.[10]

Figure C-4
SUBJECT ANALYSIS OF SEARCH QUESTIONS

Question Number	Brief Description of Subject
020	Aircraft design for airconditioning
021	NAFEC Fire-control reports
023	Aerial photography
024	Helicopter pilots
026	Bright displays for ATC
029	Tire-hydroplaning
032	Snow removal
034	FAA policy, per Halaby speeches
038	Control of birds by sound
218	National Runway markers
035	Delays at National Airport
037	Paper by Botts
008	Accuracy of air traffic controllers
012	Radiofrequency mission of thunderstorms
031	Efficiency of aircraft production industries
085	Reliability of Semiconductors
011	FAA; Inventory
189	FAA installations
001	Propeller blades
002	Icing, snow on VOR
003	Reliability of electronic components
005	Stall
196	VOR/DME
220	Stall

SUBJECT ANALYSIS OF SEARCH QUESTIONS

Question Number	Brief Description of Subject
093	Hazard from rocket launches
094	Speeches by Halaby
095	Cost and accidents
096	Air cargo security
100	Pilot Proficiency
101	Noise prediction
103	Alpha numeric displays
104	Runway roughness
105	ATC
106	ATC age
107	ATC simulators
108	Swept-wings
109	Birds and collision
110	Hydrofoils
111	SST
112	Weather and sonic boom
113	ATC
250	Cost effectiveness; personnel
251	Crash recorder
252	Voice recorder
253	Crash locator Beacon
254	Columbian
267	Concorde airplane
255	Simulators; FAA

SUBJECT ANALYSIS OF SEARCH QUESTIONS

Question Number	Brief Description of Subject
188	FAA
050	Aircraft noise
052	System Reliability
053	Batteries
054	Student exam failures
055	Near misses
056	Noise alternation
058	Statistics re airports
059	Transponders
060	Contract officers
061	ILS use by pilots
070	Economics of Air Transportation
071	SST
072	One Report
073	Tying aircraft down
074	Aircraft and Sand Strip
085	Reliability of semiconductors
086	ATC centers
087	Shock waves from supersonic aircraft
088	Reliability of electronic components
089	Sonic boom
090	An airplane's airconditioning and window design
091	BLEU I
092	Fog

SUBJECT ANALYSIS OF SEARCH QUESTIONS

Question Number	Brief Description of Subject
150	Precipitation
151	Airborne radios
153	Anti-skid devices
154	Runway roughness
155	Anti-locking device
160	Use of computers
161	SST from 1950's
162	Sonic boom
163	Flight plans
164	Safety speeches by Halaby
165	Duration of winds
166	History of ATC in the 1950's
167	Subsonic jets in the 1950's
170	ATC
172	ATC
173	Positive control
174	Density altitude
175	Collision avoidance
176	SST
177	Aircraft fuel
178	Instrument landing approach
179	Ocean ATC
180	Nose-loading aircraft
186	Aging of man

SUBJECT ANALYSIS OF SEARCH QUESTIONS

Question Number	Brief Description of Subject
230	Antenna side-lobe suppression
231	Aircraft lighting and marking
232	Decompression in aircraft
234	ATC data handling and display
235	Maneuvering in final approach
236	Airport management
120	Blue lights in radar rooms
121	Statistical analysis
122	Man-machine systems
222	Snow, ice hazards
223	Bird hazards
125	Ocean ATC
126	Bright lights
127	CO detection
224	Airborne antennas
130	Fuel tanks
133	Frequency spectra of gusts
135	SST Navigation
209	GCA
140	Airport delays
141	Doppler radar
142	Radar remoting
143	Blind spots at airports
225	ATC

SUBJECT ANALYSIS OF SEARCH QUESTION

Question Number	Brief Description of Subject
256	Airworthiness
257	Aircrago
258	Radar Beacons
259	Radar Reflectivity
260	TACAN
261	Engine Failure
262	Speech by Halaby
263	Microminiaturization
264	Radio isotopes
265	Alpha numerics
266	Pricing; airports
270	Aircraft noise
271	Turbulence and Helicopters
272	V/STOL lift fan
273	Slot Antennas
274	Halaby
275	Dean
276	Birds and runways
277	VOR/DME
279	Digital Communications Testing
280	Aptitude tests
281	Mathematical models; radar
282	Cost Savings: ATC
278	Approach landings
019	Aircraft Navigation Systems

SUBJECT ANALYSIS OF SEARCH QUESTIONS

Question Number	Brief Description of Subject
233	Arresting for aircraft
229	Constant Mach numbers for cruising
200	Population trend, vehicle trends
195	Aircraft tires
197	Statistical detection, digital communication
198	All FAA reports on weather
199	Reports on propeller blades
006	ATC training, accuracy
007	Runway arresting devices
013	N.J. and N.Y. airports and jetports
014	Aircraft navigation, VOR and VORTAC
015	B-707 VORTAC
016	Daylight lights
017	FAA; decision-making
018	Aircraft position lights
300	Noise in ATC towers
301	Cost of All-weather Landing
302	Long-Range Planning
303	Airport Management
304	Materials to Remove Runway Glare
305	Time Effectiveness
306	B-720 Response to Runway Lighting
307	Integrated Circuits

SUBJECT ANALYSIS OF SEARCH QUESTIONS

Question Number	Brief Description of Subject
309	Microwave Propagation
310	Defruiting
311	TACAN (an Identifier)
312	Project Searchlight
313	Air Pollution
314	Short-haul Aircraft
316	Effects of Oxygen on A/C Crews
317	Terminal Area Air Traffic Operations
318	Fog Dissipation
319	Radar Resolution
320	Reliability; Maintainability; Quality Control
321	VORTAC
322	Aviation in Emerging Nations
323	A/C and Air Pollution
324	Steep-Gradient Aircraft
325	Decentralization
326	Cost Effectiveness
327	Reliability of Transistors
328	Air Traffic Control Bibliography
329	Air Traffic Controllers (Retirement)
330	Air Traffic Controllers (Stress)
331	Statistical Analysis
332	PERT

SUBJECT ANALYSIS OF SEARCH QUESTIONS

Question Number	Brief Description of Subject
333	Communication and Navigation Aids
334	Capture Effect Glide Scopes

REFERENCES

1. Federal Aviation Agency. 1964. Thesaurus of FAA Descriptors. Washington, D. C. (July)

2. Taube, Mortimer. 1953. Evaluation of Information Systems for Report Utilization. 1953. Studies in Coordinate Indexing. Washington, D. C. Documentation, Inc., v.1: 97-110.

3. Shaw, R. R. 1963. Information Retrieval. Science, 140: 609 (May 10).

4. Klempner, Irving M. 1964. Methodology for the Comparative Analysis of Information Storage and Retrieval Systems: A Critical Review. American Documentation, 15: 210-216 (July).

5. National Academy of Sciences, National Research Council. 1964. The Metallurgical Searching Service of the American Society for Metals -- Western Reserve University: An Evaluation. Publication 1148.

6. Aitchison, J., and Cleverdon, C. W. 1963. ASLIB Cranfield Research Project. Report of a Test on the Index of Metallurgical Literature of Western Reserve University. Cranfield, England: College of Aeronautics.

7. Swets, John A. 1963. Information Retrieval Systems: Statistical Decision Theory May Provide a Measure of Effectiveness Better than Measures Proposed to Date. Science, 141: 245-50 (July 19).

8. Doyle, Lauren B. 1963. Is Relevance an Adequate Criterion in Retrieval System Evaluation? System Development Corporation, Santa Monica, California. SP-1262: 3 (July 1).

9. Andersen (Arthur) & Company. 1962. Research Study on Criteria and Procedures for Evaluating Scientific Information Retrieval Systems. Final Report: 31-33 (March).

10. Atherton, Pauline. 1964. Proposed Standard Description for Evaluation Tests of Retrieval Systems. (November).

GLOSSARY

(Definitions that fit the Federal Aviation Information Retrieval System)

CONCEPT INDEXING: The intellectual process of choosing the concepts in a particular document or search question that are of sufficient importance for retrieval.

EXHAUSTIVITY: The selection of many concepts during concept indexing.

POST ALSO: An order, dictated by the thesaurus, which requires that generic terms be posted in the file (Termatrex cards) when any of their respective specific terms had been selected for indexing.

RECALL: When the word is used alone, it becomes synonymous with retrieval.

RECALL RATIO: The number of relevant documents retrieved for a search, divided by the total number of relevant documents in the collection; multiplying by 100 gives recall ratio in a percentage.

RELEVANCE: A qualitative trait of a document having "direct bearing" on a particular search question.

RELEVANCE RATIO: The number of relevant documents retrieved for a search, divided by the total number of documents retrieved for that search.

SPECIFICITY: Concept indexing that chooses terms that are co-extensive with a concept. (Many terms chosen for one concept is a high level of specificity.)

TERM WEIGHTING: A notation (an asterisk) placed adjacent indexing terms by an indexer to indicate the greater importance that that term has.

APPENDIX D

DETAILED RESULTS OF THE EFFECTIVENESS TEST

LIST OF ILLUSTRATIONS

Figure D-1
RETRIEVAL DATA: Question 57

Report Number	Relevance (R)	Strategy A		Strategy B		Strategy C		Strategy D	
		Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant
0078	R			x					
0881					x				
0931	R			x					
1050					x				
1069			x						
1081					x				
1124	R	x		x					
1145	R	x		x					
1155	R	x		x					
1161	R	x		x					
1743					x				
2051			x		x				
2950					x				
3226					x				
3290					x				
3836					x				
3866					x				
4119					x				
4152					x				
4511					x				
4849					x				
5857	R	x		x					
5877					x				
5904					x				
6416	R			x					
6814					x				
* 7066	R			x					
7268					x				
7271	R	x		x					
7272	R	x		x					
7352					x				
8124					x				
8240					x				
9716					x				
Total (Set A)	11	7	2	11	22	-	-	-	-
(Set B)	1	0	-	1	-	-	-	-	-

* Reports from Document Set B

Figure D-2
RETRIEVAL DATA: Question 85

Report Number	Relevance (R)	Strategy A		Strategy B		Strategy C		Strategy D	
		Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant
0645									
1199					x		x		
*1764	R			x		x		x	
2256					x		x		
2835					x		x		x
3238					x		x		
*3336	R								
3532	R			x		x		x	
3988					x		x		x
4059	R			x		x		x	
4072	R	x		x		x		x	
4132					x		x		x
4232					x		x		x
4309	R	x		x		x		x	
4479					x		x		x
4481					x		x		x
4549	R			x		x		x	
4680	R	x		x		x		x	
*4744	R			x		x		x	
4790					x		x		x
4955					x		x		x
5008					x				
5846									
7194									
7540					x		x		x
7561									
8177					x		x		x
8736									
8834			x		x		x		
9066									
9129									
9218	R			x		x		x	
9298			x		x				x
9328									

RETRIEVAL DATA: Question 85 (Continued)

Report Number	Relevance (R)	Strategy A		Strategy B		Strategy C		Strategy D	
		Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant
9389					x		x		x
9439					x		x		x
9588									
9756									
9786					x		x		x
9803					x		x		x
9806									
9827					x		x		x
Total									
(Set A)	10	3	2	9	21	9	20	9	16
(Set B)	3	0	-	2	-	2	-	2	-

Reports from Document Set B

Figure D-3

RETRIEVAL DATA: Question 88**

Report Number	Relevance (R)	Strategy A		Strategy B		Strategy C		Strategy D	
		Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant
*0645					x		x		x
*1764	R			x		x		x	
*3336	R			x		x			
*4101					x		x		
*4132	R			x		x		x	x
*4685	R								
*4744	R			x		x		x	
*9298					x		x		x
Total (Set B)	5	0	0	4	3	4	3	3	3

* Reports for Document Set B

**Data from Set B only.

Figure D-4

RETRIEVAL DATA: Question 109

Report Number	Relevance (R)	Strategy A		Strategy B		Strategy C		Strategy D	
		Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant
0947					x		x		
1027					x		x		
1246					x		x		
1325	R	x		x		x		x	
1328	R	x		x		x		x	
1370	R			x		x		x	
1380	R	x		x		x		x	
1507					x		x		x
1542					x		x		
1552	R	x		x		x		x	
* 1563	R	x		x		x		x	
* 1591	R	x		x		x		x	
159-	R	x		x		x		x	
* 1623	R	x		x		x		x	
1785					x		x		x
1856	R	x		x		x		x	
1930					x				
2276					x				
2397					x		x		
2713					x		x		
2943	R			x		x			
3617					x				
4485					x				
5175					x				
6090					x		x		
6239					x		x		
* 6438	R			x		x		x	
* 6879	R	x		x		x		x	
7031					x		x		
7672					x				
7695					x				
7808					x				
7831					x				x
7854					x		x		

RETRIEVAL DATA: Question 109 (Continued)

Report Number	Relevance (R)	Strategy A		Strategy B		Strategy C		Strategy D	
		Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant
7855					x		x		
7925					x		x		
8110					x		x		
8357					x		x		
9015	R	x		x		x		x	
9778					x		x		
9979					x		x		
Total									
(Set A)	14	11	0	14	27	14	18	13	3
(Set B)	5	4	-	5	-	5	-	5	-

* Reports from Document Set B

Figure D-5

RETRIEVAL DATE: Question 111

Report Number	Relevance (R)	Strategy A		Strategy B		Strategy C		Strategy D	
		Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant
0130			x		x		x		x
0812					x		x		x
0824					x		x		x
1053					x		x		
1111					x		x		
1684					x		x		
1868					x		x		x
3548					x		x		
3614					x		x		
* 4513	R			x		x		x	
5140					x		x		x
5193					x		x		x
5195					x		x		
5252					x		x		
5261					x		x		
5263					x		x		x
* 5297	R			x		x		x	
5305					x		x		
5306					x		x		x
* 5307	R			x		x			
* 5334	R			x		x			
5371					x		x		
5377					x		x		
* 5401	R			x		x			
5402					x		x		
5403					x		x		
* 5512	R			x		x			
5513					x		x		x
5600					x		x		
5603					x		x		x
5604					x		x		
5612			x		x				x
5617					x		x		x
5627					x		x		x
5632					x		x		x
5633					x		x		x

RETRIEVAL DATA: Question 111 (Continued)

Report Number	Relevance (R)	Strategy A		Strategy B		Strategy C		Strategy D	
		Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant
5642					x		x		
5659					x		x		
5666					x		x		x
5667					x		x		x
5675					x				x
5684	R			x		x	x		x
5687					x		x		
5689					x		x		x
5692					x		x		
5698					x				x
5702					x				x
5703					x		x		x
* 5717	R			x	x		x		x
5720					x		x		
5723					x		x		x
5724					x		x		x
5725	R			x		x		x	
* 6204	R								
6451	R			x		x			
* 6463	R			x		x		x	
6464					x		x		
6480			x		x		x		
6481					x		x		x
6499					x		x		x
6500					x		x		x
6526	R			x		x		x	
6533	R			x		x			
6535					x		x		
6536					x		x		
6539	R			x		x			x
* 6567	R			x		x			
6575	R			x		x			
6626					x		x		
6881					x		x		x
7575					x		x		x

RETRIEVAL DATA: Question 111 (Continued)

Report Number	Relevance (R)	Strategy A		Strategy B		Strategy C		Strategy D	
		Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant
8053	R			x		x			
8109					x		x		
8249					x		x		
* 8359	R								
8373					x		x		
8416					x		x		
8441	R			x		x		x	
8479	R			x		x			
8493					x		x		x
8553					x		x		
8716					x		x		
9501	R			x		x			
9638			x		x		x		x
9991					x		x		x
Total (Set A)	22	0	5	20	63	20	60	6	36
(Set B)	11	0	-	9	-	9	-	4	-

* Reports from Document Set B

Figure D-6
RETRIEVAL DATA: Question 162

Report Number	Relevance (R)	Strategy A		Strategy B		Strategy C		Strategy D	
		Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant
0725	R	x		x		x		x	
0891			x		x		x		x
*1026	R	x		x		x		x	
1064	R			x				x	
1076	R							x	
1094			x		x		x		x
1137	R	x		x		x		x	
1138			x		x		x		x
1177			x		x		x		x
1180	R	x		x		x		x	
1183			x		x		x		x
*1188	R	x		x				x	
1189			x		x				x
1192	R			x		x		x	
1195	R	x		x		x		x	
1196									
1215	R			x		x			
1216			x		x		x		x
1223					x				
1224	R	x		x				x	
1226	R	x		x				x	
1611					x		x		
1679			x		x				x
*2036	R	x		x		x		x	
2154	R	x		x		x		x	
2161	R			x					
2268	R	x		x		x		x	
2269	R	x		x		x		x	
2347					x		x		
2389					x		x		x
2507			x		x		x		x
2682					x		x		
2689	R			x		x			

RETRIEVAL DATA: Question 162 (Continued)

Report Number	Relevance (R)	Strategy A		Strategy B		Strategy C		Strategy D	
		Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant
2733					x				
2783					x				
3006					x		x		
3010			x		x				x
*3093					x		x		x
3803	R			x		x		x	
3931			x		x		x		x
4040	R			x				x	
4332									x
4334	R			x		x		x	
4344					x		x		
4347			x		x		x		x
4369					x		x		
4386	R	x		x		x		x	
*4394	R	x		x		x		x	
4395	R	x		x				x	
4841			x		x		x		x
5068					x				x
5094	R	x		x		x		x	
5118			x		x		x		x
*5147	R			x				x	
*5269	R								
5337					x		x		x
5406					x				x
5442	R	x		x		x		x	
5655					x		x		
5825			x		x		x		x
5894			x		x		x		x
6066					x		x		x
6067			x		x		x		x
6085			x		x		x		x

RETRIEVAL DATA: Question 162 (Continued)

Report Number	Relevance (R)	Strategy A		Strategy B		Strategy C		Strategy D	
		Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant
6169			x		x		x		x
6181					x		x		
*6596	R								
6906					x				x
7124					x		x		
7928					x		x		x
8051	R			x		x		x	
8105	R			x		x		x	
8106	R			x		x		x	
8108	R	x		x		x		x	
8328	R			x				x	
*9056			x		x		x		x
9082					x		x		
9237					x				
9631	R	x		x		x		x	
Total									
(Set A)	35	19	21	32	45	24	33	30	29
(Set B)	7	4	-	5	-	3	-	5	-

Figure D-7
RETRIEVAL DATA: Question 205

Report Number	Relevance (R)	Strategy A		Strategy B		Strategy C		Strategy D	
		Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant
1091			x		x		x		x
1179					x		x		
1949	R	x		x		x		x	
1950					x		x		
1961					x		x		
2488					x		x		
2567					x		x		
2596	R			x		x		x	
2841					x		x		x
2852					x		x		x
2916					x		x		x
3225					x		x		
3646	R			x		x		x	
3942					x		x		x
4039	R			x		x		x	
4041	R			x		x		x	
4206					x		x		x
4241	R	x		x		x		x	
4315	R			x		x		x	
4316					x		x		x
4317					x		x		x
4340	R			x		x		x	
4345					x		x		
4701									
4728					x		x		x
4841					x		x		
4862	R			x		x		x	
4968					x		x		x
5067	R			x		x		x	
5086					x		x		x
5291					x		x		x
5357					x		x		x
5438	R	x		x		x		x	
5901									x
5931					x		x		
6014					x		x	x	
6103					x		x		x

RETRIEVAL DATA: Question 205 (Continued)

Report Number	Relevance (R)	Strategy A		Strategy B		Strategy C		Strategy D	
		Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant
6104					x		x		x
6177					x		x		
6179					x		x		
6180					x		x		
6181					x		x		
6237					x		x		
6310					x		x		x
6312					x		x		x
6313	R	x		x		x		x	
6314					x		x		x
6315			x		x		x		x
6857	R			x		x		x	
7227					x		x		x
7401	R	x		x		x		x	
7585	R	x		x		x		x	
7634					x		x		x
8210					x		x		x
8279					x		x		x
8511					x		x		
8686			x		x		x		x
8815					x		x		x
8939					x		x		x
* 9152	R								
9479					x		x		
9647			x		x		x		x
9734			x		x		x		x
7964					x		x		
Total (Set A)	16	6	5	15	46	15	46	15	29
(Set B)	1	0	-	0	-	0	-	0	-

* Reports from Document Set B

Figure D-8
RETRIEVAL DATA: Question 223B

Report Number	Relevance (R)	Strategy A		Strategy B		Strategy C		Strategy D	
		Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant
0433									
0664	R	x		x		x		x	
1316									
1325									
1328									
1370									
1380									
1552									
1503									
1591									
1597									
1623									
1856									
2713	R			x		x		x	
2443									
4126									
* 5192	R								
6438									
6871					x		x		x
6879									
8357									
9015									
Total									
(Set A)	3	1	0	2	1	2	1	2	1
(Set B)	1	0	-	0	-	0	-	0	0

* Reports from Document Set B

Figure D-9

RETRIEVAL DATA: Question 223A

Report Number	Relevance (R)	Strategy A		Strategy B		Strategy C		Strategy D	
		Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant
0433									
0664	R			x		x		x	
1316	R			x		x		x	
1856									
2713	R			x		x		x	
*5192	R			x		x		x	
*5229	R								
*6879	R								
6903					x				x
8357									
*9978	R								
Total (Set A)	7	0	0	4	1	4	0	4	1
(Set B)	4	0	-	1	-	1	-	1	-

* Reports from Document Set B

Figure D-10

RETRIEVAL DATA: Question 133

Doc. Number	Relevance (R)	Strategy A		Strategy B		Strategy C		Strategy D	
		Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant
2536	R	x		x		x		x	
5357					x		x		
5888									
6730					x		x		x
8210					x		x		x
8858					x		x		x
Total (Set A)	1	1	0	1	4	1	4	1	3
(Set B)	0	0	-	0	-	0	-	0	-

Figure D-11
RETRIEVAL DATA: Question 270

Report Number	Relevance (R)	Strategy A		Strategy B		Strategy C		Strategy D	
		Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant
0071	R			x		x		x	
* 0712	R			x		x			
0742					x				
0933					x		x		x
1053					x		x		x
1064	R			x		x		x	
1070					x		x		x
1076					x		x		
1094	R			x		x		x	
* 1188	R			x		x		x	
1189	R			x		x		x	
1215	R			x		x		x	
1226	R			x				x	
1275	R			x		x			
1306					x				
1360					x				
1581					x				
1853	R			x		x			
1868					x				
1941					x				
2093					x				
* 2883	R			x		x			
3006	R			x		x		x	
3803					x		x		x
3905					x				
4040	R			x		x		x	
4334	R			x		x		x	
4354	R			x		x		x	
4500					x		x		
5052	R			x		x		x	
* 5147	R	x		x		x		x	
* 5269	R	x		x				x	
5349					x				
5406	R			x		x		x	
5506	R			x		x			
5513					x				
5603					x		x		
5620					x				
5623					x		x		x
5649	R			x		x		x	
5655	R			x		x		x	

RETRIEVAL DATA: Question 270 (Continued)

Report Number	Relevance	Strategy A		Strategy B		Strategy C		Strategy D	
		Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant	Relevant	Non-Relevant
5661	R			x		x		x	
5665	R	x		x		x		x	
5666	R			x		x			
5669	R			x		x		x	
* 5680	R			x		x			
5708	R			x		x		x	
5713					x		x		x
6448					x		x		x
6450	R			x		x		x	
6539					x		x		x
7619					x				
7620					x				
7625					x		x		
7689	R			x		x		x	
7977					x		x		
8050	R			x		x			
8051	R			x		x		x	
8105					x		x		x
8106					x		x		x
* 8344	R								
8415					x				
8487					x				
Total (Set A)	33	3	0	32	30	30	15	24	10
(Set B)	7	2	-	6	-	5	-	3	-

* Reports from Document Set B

Figure D-12

RETRIEVAL DATA FOR SOURCE DOCUMENT QUESTIONS

(x · Retrieval)

Question Number	STRATEGY			
	A	B	C	D
1	x	x	x	x
2	x	x	x	x
3	x	x	x	x
4		x	x	
5	x	x	x	
6	x	x	x	x
7	x	x		
8	x	x		x
9	x	x	x	x
10				
11	x	x	x	x
12	x	x	x	
13		x	x	x
14		x	x	x
15		x	x	x
16	x	x	x	x
17	x	x	x	x
18				
19	x	x	x	x
20	x	x	x	x
TOTAL	14	18	17	15
RECALL RATIO	70%	90%	85%	75%

Figure D-13

LIST OF TEST QUESTIONS

57. What types of available snow and ice removal equipment are suitable for use on airport runways, taxiways, aprons, etc?

85. What methods are available for determining the reliability of semiconductors?

88. What is the current state-of-the-art with respect to measuring the reliability of electronic components, particularly transistors, capacitors, relays, and resistors?

109. What are the hazards to aircraft colliding with other objects in flight, such as birds, weather balloons, etc? Fixed objects (water towers, power lines, antennas, etc.) and other aircraft are not to be considered.

111. What effect will the introduction of supersonic transports into the civil air fleet have on the cost of the air traffic control system (i.e., cost of retraining, new navigation aids, more personnel, etc.)?

133. What methods are available for forecasting thunderstorms by passive detection? What spectral data is available on the emissions (if any) from thunderstorm clouds?

162. What are the technical and social problems imposed by jet engine noise (not sonic booms), including methods for reducing or suppressing it?

205. What methods are available for the measurement and detection of high-altitude clear air turbulence? What is the frequency, geographical, and altitude distribution of clear air turbulence?

223A. What accident hazards do birds present to aircraft during take-off and landing?

223B. What methods ("scare devices") are available for ridding terminal areas of birds?

270. What information is available on airport land use planning with regard to aircraft noise?

Figure D-14
LIST OF SOURCE DOCUMENT QUESTIONS

1. What materials can be added to fuels to prevent icing?
2. Identify tests of radio transmitter-receivers.
3. Find reports with data on the lift characteristics of double-slotted-flaps on swept-back wings.
4. What has been done on the use of millimeter wave superheterodyne receivers in radiometers?
5. What information is available on the use of binary coding in digital communications systems?
6. Need information on performance of traveling wave antennas, particularly the gain limitations and phase modulations.
7. What effect does the use of mid-chord flaps have on take-off performance?
8. What has been done to develop automated graph reading for computer input?
9. What chamicals are available for removing ice from pavements and runways?
10. What are some of the disturbances and annoyances of aircraft and airports that cause communities to oppose their location?
11. What studies exist for detecting aircraft in the terminal area, that is, airport surface traffic with radio-doppler sensors?
12. Need a functional description of the facilities needed for data processing systems that can be used for ATC.
13. What are some of the requirements of ATC display that include weather communication?
14. Identify studies that establish the limits for "degrees of smoothness" beyond which a runway or taxiway is defined as rough.
15. What methods are available for predicting the output signal-to-noise ratio of an amplitude modulated radio receiver?
16. What is the effect of training on the performance of electronics maintenance personnel in aviation?
17. Want detailed information on bright displays, particularly circuits for alpha numeric data and symbolic data.

18. Find information on the reduction of flight plan into optimum flight headings and altitudes.

19. What is the accuracy of position reporting under IFR?

20. How can altitude be coded and read in an air traffic control system?

APPENDIX E

DESCRIPTORS ADDED TO THE THESAURUS

APPENDIX E
DESCRIPTORS ADDED TO THE THESAURUS

ABRASIVES
(Materials (Application))

AERIAL PICKUP SYSTEMS
(Aircraft Equipment)

AIR-DROP OPERATIONS
(Military Operations)

AIR FORCE LOGISTICS COMMAND
(Military Organizations)

AIR SCOOPS
(Engines and Engine Operations)

AIRCRAFT INTERCEPTION
(Detection and Tracking)

ALGEBRA
(Mathematics)

ALUMINUM COMPOUNDS
(Chemical Compounds)

AMMETERS
(Electrical and Electronic Measurement)

ANGLE OF ARRIVAL
(Electromagnetic Wave Phenomena)

ANODES (ELECTROLYTIC CELL)
(Electric Power Sources)

ANTIFOGGING AGNETS
(Materials (Application))

ARC-WELDING
(Metal Joining)

ARMAMENT
(Warfare and Weapons)

ARMY EQUIPMENT
(Logistics)

ARSENIDES
(Chemical Compounds)

ARTIFICIAL INTELLIGENCE
(Bionics)

ATMOSPHERE MODELS
(Models)

ATMOSPHERIC TIDES
(Meteorology and Climatology)

ATTACK BOMBERS
(Aircraft)

AUTOGYRO ROTORS
(Aerodynamic Configurations)

*AUTOMATIC FREQUENCY CONTROL
(Electrical and Electronics Equipment)

*AUTOMATIC LANDING SYSTEMS
(Aeronautics)

*AWARDS
(General Services and Supplies)

BACKGROUND
(Abstract Concepts)

BACKWARD-WAVE TUBES
(Electron Tubes)

BARIUM COMPOUNDS
(Chemical Compounds)

BAROMETERS
(Meteorological Aids)

*Non-ASTIA descriptors

BESSEL FUNCTIONS
(Mathematics)

BLEED SYSTEMS
(Hydraulic and Pneumatic Systems)

BLOOD CHEMISTRY
(Biochemistry)

*BOMB DETECTION
(Safety and Accidents)

BORANES
(Chemical Compounds)

BORON
(Chemical Compounds)

BORON COMPOUNDS
(Chemical Elements)

BURNS
(Wounds and Injuries)

CADMIUM
(Chemical Elements)

CALCIUM
(Chemical Elements)

CAPACITANCE BRIDGES
(Electrical and Electronic Equipment)

CAPTIVE TESTS
(Laboratories and Test Facilities)

CARBON
(Chemical Elements)

CARBON ARC LAMPS
(Instrumentation)

CARBON BLACK
(Materials)

CARRIERS (RADIO WAVES)
(Radio)

CATHODE FOLLOWERS
(Electrical and Electronic Circuits)

CATHODES
(Electrical and Electronic Equipment)

CELLULOSIC PLASTICS
(Plastics)

CENTRAL NERVOUS SYSTEM
(Anatomy)

CERAMIC COATINGS
(Finishes and Finishing)

CHEMICAL MILLING
(Industrial and Laboratory Processes)

CHILDREN
(Personnel)

CHROMIUM
(Chemical Elements)

CIVIL ENGINEERING
(Research Fields)

*CLEAR AIR TURBULENCE
(Meteorology and Climatology)

*CLEARANCE
(Aeronautics)

COHERENT RADAR
(Radar)

COMBUSTION PRODUCTS
(Combustion)

COMPRESSOR NOISE
(Acoustics)

CONDUCTIVITY
(Physical and Physicochemical Concepts)

*CONFERENCES
(Documentation)

CONVERGENT-DIVERGENT NOZZLES
(Rockets)

CONVEX SETS
(Mathematics)

COOLANTS
(Materials (Application))

CORNEA
(Anatomy)

*COUPLERS
(Electrical and Electronic Equipment)

*CRASH TESTING
(Laboratories and Test Facilities)

CRIMINOLOGY
(Social Sciences)

*CRUISING
(Aeronautics)

CRYSTAL OSCILLATORS
(Electrical and Electronic Equipment)

CUMULUS CLOUDS
(Meteorology and Climatology)

DACRON
(Textiles and Fibers)

DESICCANTS
(Materials (Application))

DISCONNECT FITTINGS
(Couplings, Fittings and Fastenings)

DISPERSION HARDENING
(Industrial and Laboratory Processes)

DRIFTMETERS
(Flight Instruments)

DUAL-ROTATION PROPELLERS
(Propulsion)

ELECTRIC PROPULSION
(Propulsion)

ELECTROLYTIC CAPACITORS
(Electrical and Electronic Equipment)

ELECTRON BOMBARDMENT
(Particle Accelerators)

ELECTRON DENSITY
(Meteorology and Climatology)

ELECTRON LENSES
(Electron Tubes)

ELECTROOPTICAL PHOTOGRAPHY
(Photography)

ELLIPSOIDS
(Geometric Forms)

EMBRYOS
(Physiology)

EMPLOYEE RELATIONS
(Social Sciences)

ENGINE SURGE
(Engines and Engine Operations)

ENGINEERING GEOLOGY
(Geology and Seismology)

EPITAXIAL GROWTH
(Crystallography)

EUTECTICS
(Materials (Physical State))

EXCITATION
(Atomic and Molecular Physics)

EXPLODING WIRES
(Ammunition and Explosives)

EXPLOSIVES INITIATORS
(Ammunition and Explosives)

FEDERAL BUDGETS
(Economics)

FIBRIN
(Proteins)

FIELD THEORY
(Electricity and Magnetism)

FILM PROJECTORS
(Photography)

FILM READERS
(Photography)

FILTERS (ELECTROMAGNETIC WAVE)
(Filters)

FLAME HOLDERS
(Combustion)

FLEXIBLE STRUCTURES
(Structural Engineering)

FOREIGN POLICY
(Social Sciences)

FOULING
(Abstract Concepts)

FOUNDATIONS (STRUCTURES)
(Structural Engineering)

FREE-FLIGHT TRAJECTORIES
(Mechanics)

FREEZING
(Physical and Physico-chemical Concepts

FUEL METERS
(Engines and Engine Operations)

FUEL THICKENERS
(Materials (Application))

FUEL TRUCKS
(Vehicles)

GAS GENERATOR ENGINES
(Engines and Engine Operations)

GROWTH
(Physiology)

GUIDED MISSILE COMPONENTS
(Guided Missiles)

GUIDED MISSILE SIMULATORS
(Guided Missiles)

GUN-LAUNCHED
(Modifiers)

*HALABY SPEECHES

HANGARS
(Structural Engineering)

HARMONIC OSCILLATORS
(Electrical and Electronic Equipment)

HEAT OF FUSION
(Thermodynamics)

HEAT TRANSFER COEFFICIENTS
(Thermodynamics)

HEMORRHAGE
(Pathology)

HIBERNATION
(Biology)

HORIZON SCANNERS
(Flight Control Systems)

HORN ANTENNAS
(Antennas)

HYDRAULIC COUPLINGS
(Couplings, Fittings and Fasteners)

HYDRIDES
(Chemical Compounds)

HYDROLYSIS
(Chemical Reactions)

HYDROPHONES
(Acoustics)

*HYDROPLANING
(Fluid Dynamics)

IMAGE INTENSIFIERS (ELECTRONICS)
(Electron Tubes)

IMPEDANCE BRIDGES
(Electrical and Electronic Equipment)

INCENDIARY PROJECTILES
(Warfare and Weapons)

INDUSTRIAL PROCUREMENT
(Logistics)

INDUSTRIAL PSYCHOLOGY
(Psychology and Psychometrics)

INDUSTRIAL RELATIONS
(Social Sciences)

INDUSTRIAL TRAINING
(Training)

INFECTIONS
(Pathology)

INFRARED SPECTROPHOTOMETERS
(Spectroscopy)

INGESTION (ENGINES)
(Engines and Engine Operations)

INTEGRATION
(Methematics)

INTESTINES
(Anatomy)

IRASERS
(Amplifiers)

IRON COMPOUNDS
(Chemical Compounds)

ISOCYANATE PLASTICS
(Plastics)

LABOR
(Social Sciences)

LABOR UNIONS
(Social Sciences)

LAUNCH VEHICLES (AEROSPACE)
(Rockets)

*LEADING EDGE
(Aerodynamic Configurations)

LOW-TEMPERATURE LUBRICANTS
(Lubrication and Bearings)

LOW-TEMPERATURE RESEARCH
(Research Fields)

LYMPHOCYTES
(Hematology)

MACHINE TRANSLATION
(Documentation)

MAGNETIC CORE STORAGE
(Computers and Data Systems)

MAGNETIC GUIDANCE
(Navigation and Guidance)

MAGNETIC STORMS
(Meteorology and Climatology)

MAGNETOMETERS
(Instrumentation)

*MAN-MACHINE SYSTEMS
(Abstract Concepts)

MARKERS
(Pyrotechnics)

MARTENSITE
(Metallurgy and Metallography)

MATCHED FILTERS
(Filters)

MATERIAL CONTROL
(Logistics)

*MC KEE

MEMBRANES
(Material (Physical State))

METALLIC CRYSTALS
(Crystallography)

MICROANALYSIS
(Chemistry)

MICROFILM
(Photography)

MILITARY PUBLICATIONS
(Documentation)

MILITARY STRATEGY
(Military Operations)

MINING ENGINEERING
(Research Fields)

MIXTURES
(Materials (Physical State))

MOBILIZATION
(Logistics)

MONEY
(Economics)

MULTIPLE OPERATION
(Abstract Concepts)

MUTATIONS
(Biology)

NAVAL EQUIPMENT
(Logistics)

NAVAL RESEARCH LABORATORIES
(Laboratories and Test Facilities)

NAVY
(Military Organization)

NEGATIVE RESISTANCE CIRCUITS
(Electrical and Electronic Equipment)

NEWSPAPERS
(Documentation)

NIGHT LANDINGS
(Aeronautics)

NOCTILUCENT CLOUDS
(Meteorology and Climatology)

NOZZLE CLUSTERS
(Rockets)

NOZZLE INSERTS
(Rockets)

NUCLEAR SPINS
(Nuclear Physics)

OBESITY
(Physiology)

OFFICE EQUIPMENT AND SUPPLIES
(General Services and Supplies)

OPERATORS (MATHEMATICS)
(Mathematics)

OPTIMIZATION
(Mathematics)

PARAMAGNETIC RESONANCE
(Electricity and Magnetism)

PARENTERAL INFUSIONS
(Medicine)

PARTICLE SIZE
(Physical and Physico-chemical Concepts)

PATENTS
(Documentation)

*PEAK AIR TRAFFIC
(Aeronautics)

PENTABORANES
(Chemical Compounds)

PERMEABILITY
(Physical and Physico-chemical Concepts)

PHASE STUDIES
(Physical and Physico-chemical Concepts)

PHOSPHORESCENCE
(Optics)

PHOSPHORUS TRANSFERASES
(Enzymes)

PHOTOGRAPHIC FILM
(Photography)

PHOTOGRAPHIC FILTERS
(Photography)

PHOTOGRAPHIC INTELLIGENCE
(Intelligence)

PIEZOELECTRIC TRANSDUCERS
(Instrumentation)

PITCH DISCRIMINATION
(Acoustics)

PLUG NOZZLES
(Rockets)

PNEUMATIC BRAKES
(Vehibles)

POLITICAL SCIENCE
(Social Sciences)

POLYNOMIALS
(Mathematics)

POROSITY
(Physical and Physico-chemical Concepts)

POROUS MATERIALS
(Materials)

POTASSIUM ALLOYS
(Alloys)

POTENTIOMETERS
(Electrical and Electronic Equipment)

PREGNANCY
(Physiology)

PRINTED CIRCUITS
(Electrical and Electronic Equipment)

PROPELLER NOISE
(Acoustics)

PULSE COUNTERS
(Electrical and Electronic Equipment)

PULSE DISCRIMINATORS
(Electrical and Electronic Equipment)

QUANTUM MECHANICS
(Research Fields)

RADAR CONFUSION REFLECTORS
(Electromagnetic Warfare)

RADAR INTERCEPTION
(Electromagnetic Warfare)

RADIO HOMING
(Navigation and Guidance)

RADIOLOGICAL WARFARE
(Warfare)

RAMJET ENGINE NOZZLES
(Engines and Engine Operations)

RAMJET INLETS
(Engines and Engine Operations)

RARE EARTH COMPOUNDS
(Chemical Compounds)

RARE EARTHS
(Chemical Compounds)

RECUITING
(Military Operations)

REFRACTORY COATINGS
(Finishes and Finishing)

ROCKET PROPELLANTS
(Finishes and Finishing)

ROTARY SWITCHES
(Electrical and Electronic Equipment)

*ROTOR HUBS
(Aircraft Structures)

ROTORCHUTES
(Aeronautics)

SATELLITE ATTITUDE
(Space Technology)

SEALS (STOPPERS)
(Adhesive and Seals)

SELENIDES
(Chemical Compounds)

SELF-SEALING COUPLINGS
(Couplings, Fittings and Fastenings)

SEMICIRCULAR CANALS
(Anatomy)

*SENSING ELEMENTS
(Instrumentation)

SEQUENCES
(Mathematics)

SHIPS
(Ships and Boats)

SILICIC ACIDS
(Chemical Compounds)

SILT
(Geology and Seismology)

SINGLE SIDEBAND COMMUNICATIONS SYSTEMS
(Communications Systems)

SINTERING
(Industrial and Laboratory Processes)

SLURRY FUELS
(Fuels)

*SLUSH
(Meteorology and Climatology)

SOLUTIONS
(Materials (Physical State))

SOUND RANGING
(Detection and Tracking)

SPACE COMMUNICATIONS SYSTEMS
(Communications Systems)

SPACE NAVIGATION
(Navigation and Guidance)

*SPACE TECHNOLOGY
(Space Technology)

SPACEBORNE
(Modifiers)

SPARK IGNITION
(Combustion)

SPECIFIC IMPULSE
(Rocket Propellants)

SPEECHES
(Documentation)

SPINNERS
(Aerodynamic Configurations)

SPRAY NOZZLES
(Fluid Dynamics)

STIFFENED CYLINDERS
(Geometric Forms)

STRAIN MECHANICS
(Mechanical Properties)

STRATUS CLOUDS
(Meteorology and Climatology)

SUBMARINE PERSONNEL
(Personnel)

SUCROSE
(Carbohydrates)

SUNSPOTS
(Astronomy)

SWEPT-FORWARD WINGS
(Aerodynamic Configurations)

SYNTHETIC STONES
(Mineralogy)

SYSTEMS ENGINEERING
(Research Fields)

TAIL HELICOPTOR ROTORS
(Aerodynamic Configurations)

TAILLESS AIRPLANES
(Aircraft)

TARGET ANGLE
(Fire Control and Bombing)

TAYLOR'S SERIES
(Mathematics)

*TECHNIQUES
(Abstract Concepts)

TELEGRAPH EQUIPMENT
(Telephone, Telegraph and Teletype)

TELESCOPES
(Optical Equipment)

TELEVISION ANTENNAS
(Antennas)

TELEVISION CONVERTERS
(Television)

TEST CONSTRUCTION (PSYCHOLOGY)
(Psychology and Psychometrics)

TETRODES
(Electron Tubes)

TEXTBOOKS
(Documentation)

THERMIONIC CONVERTERS
(Electric Power Sources)

THERMOELECTRICITY
(Electricity and Magnetism)

THORIUM ALLOYS
(Alloys)

TITANIUM COMPOUNDS
(Chemical Compounds)

TOGGLE SWITCHES
(Electrical and Electronic Equipment)

TOUGHNESS
(Mechanical Properties)

TOXINS & ANTITOXINS
(Pharmacology)

TRANSITION TEMPERATURE
(Physical and Physicochemical Concepts)

TRANSPORT PROPERTIES
(Physical and Physico-chemical Concepts)

TROPOPAUSE
(Meteorology and Climatology)

TUNGSTEN ALLOYS
(Alloys)

TUNING DEVICES
(Electrical and Electronic Equipment)

TWILIGHT
(Meteorology and Climatology)

UNDERGROUND EXPLOSIONS
(Explosions)

UNDERGROUND STRUCTURES
(Structural Engineering)

UNIVERSITIES
(Social Sciences)

VACUUM APPARATUS
(Instrumentation)

VACUUM SEALS
(Adhesives and Seals)

VAPOR PRESSURE
(Physical and Physico-chemical Concepts)

VARIABLE-INCIDENCE WINGS
(Aerodynamic Configurations)

VARIABLE-SWEEP WINGS
(Aerodynamic Configurations)

VECTOR ANALYSIS
(Mathematics)

VESTIBULAR APPARATUS
(Anatomy)

VIABILITY
(Physiology)

VOLTMETERS
(Electrical and Electronic Measurement)

VORTEX THERMOMETERS
(Instrumentation)

WALKIE-TALKIES
(Radio)

WASTE GASES
(Sanitary Engineering)

WATER INJECTION
(Engines and Engine Operation)

WATER SUPPLIES
(Oceanography and Hyrology)

WATTMETERS
(Electrical and Electronic Equipment)

WAVE ANALYZERS
(Instrumentation)

WAVEGUIDE CIRCULATORS
(Electrical and Electronic Equipment)

WEAPONS
(Warfare and Weapons)

ZINC COMPOUNDS
(Chemical Compounds)

APPENDIX F

DESCRIPTORS DELETED FROM THE THESAURUS

APPENDIX F

DESCRIPTORS DELETED FROM THE THESAURUS

ABSORPTION BIOLOGICAL

ALKALI METAL ALLOYS

ALKALI METAL COMPOUNDS

ALKALINE EARTH COMPOUNDS

ALKALINE EARTH METALS

ALKALOIDS

ANTHELMINTICS

ANTICONVULSANTS

ANTIMALARIALS

ANTISONAR COATINGS

ARMOR

ARTHROPODS

AZIDES

BARBITURATES

BASES (CHEMISTRY)

BILIARY SYSTEM

BIOLOGICAL PRODUCTS

BIOSYNTHESIS

BLOOD GROUPS

BONE MARROW

CARBONATE MINERALS

CARDIOACTIVE AGENTS

CHALCOGENS

CHARGES (EXPLOSIVE)

CHECK VALVES

CHEMICAL EQUILIBRIUM

CHLORPROMAZINE

CHROMOPROTEINS

CINCHONA ALKALOIDS

COMPRESSOR PARTS

CONTROLLABLE-THRUST ROCKET MOTORS

CRYPTOGRAPHY

CULTURE

CUTTING TOOLS

CYANATES

DECEPTION

DIAPHRAGMS (MECHANICS)

DISTANCE-TO-GO MARKERS

DUAL-THRUST ROCKET MOTORS

ELECTRIC BRIDGES

ELECTROSTATIC GENERATORS

EMBOLISM

EMBRYONATED EGG TECHNIQUE

END ORGANS

ENGINE AIR SYSTEMS COMPONENTS

ENGINE CLUSTERS

EUBACTERIALES

FAULTS (GEOLOGY)

FIBERS (NATURAL)

FIBRIN

FIELD WIRE

FIRE CONTROL COMPUTERS

FIRE CONTROL SYSTEM COMPONENTS

FIRING TESTS (ORDNANCE)

FLUORESCENT SCREENS

FLUXMETERS

FOLDS (GEOLOGY)

FOOD DISPENSING

FUZE FUNCTIONING ELEMENTS

GAS FILTERS

GEMS (MINERALS)

GLASS SEALS

GROUP VIII ELEMENTS

GUIDED MISSILE MODELS

HALIDES

HEALTH PHYSICS INSTRUMENTATION

HEAT ENGINES

HEMOPOIETIC SYSTEM

HEXOSES

HYDRIDES

IMAGE MOTION COMPENSATION

INDUSTRIAL EQUIPMENT

INFRARED PHENOMENA

INTEGUMENTARY SYSTEM

INTERNAL COMBUSTION ENGINE NOISE

ISOTOPES

JOURNAL BEARINGS

LACTOBACILLACEAE

LIFE SPAN

LINEAR ACCELERATORS

LIQUID FILTERS

LIQUID LEVEL CONTROL

LITHOSPHERE

MAGNUS FORCE

MARINE SAFETY EQUIPMENT

MARKERS

MATERIAL REMOVAL

MATERIAL SEPARATION

METALLOID ALLOYS

METALLOIDS

MICROPALEONTOLOGY

MILITARY TACTICS

MINERALS

MORPHOLOGY (BIOLOGY)

MOSAICS (LIGHT SENSITIVE)

MYDRIATICS

NAVAL SHORE ESTABLISHMENTS

NAVAL VESSELS (COMBATANT)

NUCLEAR PARTICLES

NUCLEAR PROPULSION

ORES (NONMETALLIC)

ORGANIC PIGMENTS

PALEONTOLOGY

PARTICLE ACCELERATOR COMPONENTS

PARTICLE ACCELERATOR TECHNIQUES

PARTICLE ACCELERATORS

PARTICLE BEAMS

PERMEABILITY

PHENOTHIAZINES

PHOSPHATES

PHOTOCATHODES

PHOTOGRAPHIC RECONNAISSANCE

PHOTOGRAPHIC RECORDING MEDIA

PIRICULARIA

POINT-INITIATING FUZES

POLYAMIDE PLASTICS

POWER PLANTS (ESTABLISHMENTS)

PROPELLING CHARGES

PSYCHOANALEPTIC AGENTS

PSYCHOTROPIC AGENTS

PUBLIC HEALTH

PURSUIT COURSES

QUINOLINE ALKALOIDS

REACTOR LATTICE PARAMETERS

REACTOR SYSTEM COMPONENTS

REPRODUCTIVE SYSTEM

RETICUL-END-THELIAL SYSTEM

ROCK FORMING MINERALS

ROCKET COMPONENTS

SANDSTONE

SEAFOOD

SEDIMENTARY ROCK

SEEDS

SENSE ORGANS

SEWAGE

SHIP AUXILIARY EQUIPMENT

SMALL TOOLS

SOCIAL SCIENCES

SOLAR ATMOSPHERE

SOLID ROCKET FUELS

SPACE PROBES

STRATEGIC WARFARE

STRATEGIC WEAPONS

STRUCTURAL GEOLOGY

SUGAR ACIDS

SURFACE-TO-UNDERWATER

TACTICAL WEAPONS

TAR

TEMPERATURE COEFFICIENT OF
REACTIVITY

THERMOPLASTICS

THYRATRONS

TRANSPORTER-ERECTORS

TUNG OIL

TURBINE PARTS

ULTRAVIOLET OPTICAL MATERIALS

ULTRAVIOLET RECEIVERS

UNDERWATER-TO-UNDERWATER

UNDERWATER TRACKING

UREIDES

URINARY SYSTEM

URONIC ACIDS

VEHICLE ACCESSORIES

VEHICLE CHASSIS COMPONENTS

VETERINARY MEDICINE

VITAMINS

WAXES

WHITE PHOSPHORUS